Environmental Report

Stormwater Relief Culvert

Village of
Shorewood Hills, WI

February 2001

STRAND
ASSOCIATES, INC.
ENGINEERS®

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February 21, 2001

Russell Anderson
Wisconsin DNR
3911 Fish Hatchery Road
Fitchburg, WI 53711

Re: Environmental Report - Stormwater Relief Culvert

Dear Mr. Anderson:

Enclosed is the Environmental Report for the proposed Stormwater Relief Culvert in the Village of Shorewood Hills. The report follows the outline format specified by the Department of Natural Resources Form 1600-1, Environmental Analysis and Decision on the Need for an Environmental Impact Statement.

Please call if you have any questions.

Sincerely,

STRAND ASSOCIATES, INC.

David K. Wolmutt, P.E.

Enclosure

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Report for
Village of Shorewood Hills

Environmental Report

Stormwater Relief Culvert

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2-22-01

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February 2001

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EXECUTIVE SUMMARY

EXECUTIVE SUMMARY

This report provides environmental and background data for a proposed stormwater relief culvert proposed to discharge to Lake Mendota. The report generally follows the outline format specified by Department of Natural Resources (DNR) Form 1600-1, Environmental Analysis and Decision on the Need For An Environmental Impact Statement.

The project proposes to construct a stormwater relief culvert in public right-of-ways between the Kohl's shopping area and the marina on Lake Mendota in the Village of Shorewood Hills. The majority of the culvert would lie beneath the Blackhawk Country Club in the Village of Shorewood Hills. The project would alleviate existing flooding problems in the University Avenue/Midvale Boulevard area.

Flooding near the University Avenue/Midvale Boulevard intersection has been a concern of both the City of Madison and Village of Shorewood Hills for over 50 years. The site is a natural depression, a former landfill, and has no overland flow route to provide drainage relief. Severe flooding has repeatedly damaged single family homes and commercial lots and closed both University Avenue, a major east-west arterial street, and Midvale Boulevard, a major north-south arterial street. Flooding has also impaired vehicular traffic on Locust Drive and rendered the intersection of Shorewood Boulevard and University Avenue impassable. The existing culvert system serving this area discharges into Willow Creek and has an hydraulic capacity less than the anticipated peak discharge for a 10-year storm.

The stormwater relief culvert is the recommended alternative of a 1997 Stormwater Management Study completed for the Village of Shorewood Hills and City of Madison. The study considered 14 flood relief alternatives. The stormwater relief culvert was found to be the most cost-effective alternative to alleviate flooding problems in the study area for a 100-year storm.

SECTION 1
PROJECT SUMMARY

1.01 GENERAL

This report provides environmental and background data for a proposed stormwater relief culvert proposed to discharge to Lake Mendota. The report generally follows the outline format specified by DNR Form 1600-1, Environmental Analysis and Decision on the Need For An Environmental Impact Statement.

The purpose of the report is to provide the DNR and other regulatory agencies supporting data necessary to complete an environmental assessment of potential project impacts.

The project location is shown in Figure 1.01-1.

1.02 PROJECT OVERVIEW

The proposed project includes construction of a relief culvert beneath the Blackhawk Country Club discharging to Lake Mendota at the Shorewood Hills Marina. A diversion structure north of the University Avenue/Midvale Boulevard intersection would direct surcharged flow in excess of the existing culvert capacity to the relief culvert. The culvert outlet structure would be above ground and located just west of the marina. An energy dissipation structure would be placed along the outlet channel draining into Lake Mendota to minimize sediment entering the lake and dissipate energy .

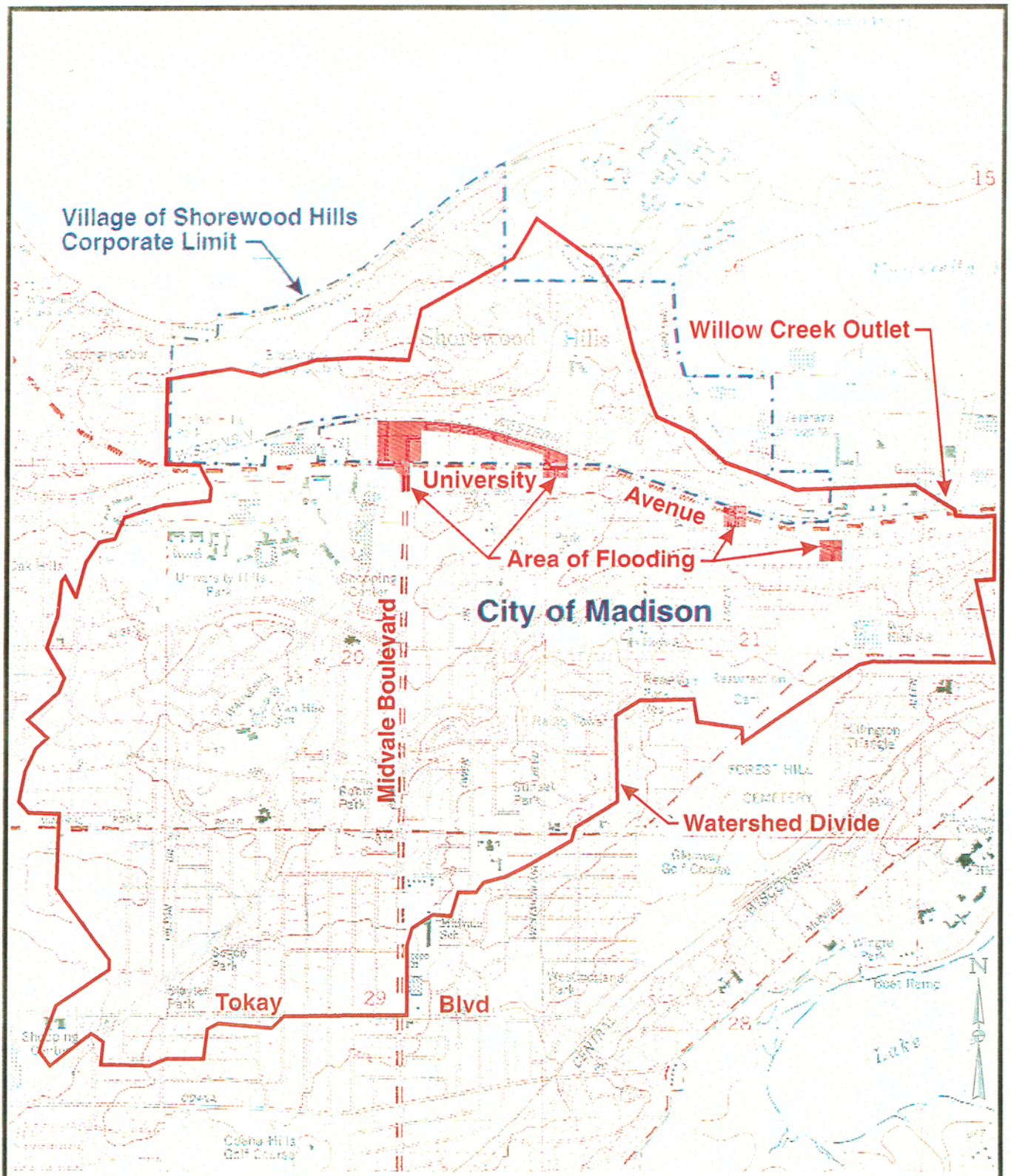
The University Avenue/Midvale Boulevard intersection is presently served by a mainline box culvert system draining northerly beneath the Kohl's grocery store, easterly along the railroad right-of-way, and discharging into Willow Creek, which in turn drains into Lake Mendota. Computer modeling indicates the existing culvert has a hydraulic capacity of only 30 percent of the anticipated inflow to the culvert for a 100-year storm and a hydraulic capacity less than the anticipated peak discharge for a 10-year storm. Stormwater in excess of the existing culvert capacity overflows to the surface through manholes and inlets, inundating the Garden Homes Subdivision, Kohl's parking lot, and the University Avenue/Midvale Boulevard intersection. A large component of the flooding in this area is also from overland runoff flow along Midvale Boulevard and University Avenue.

The goal of the proposed project is to relieve flooding in the Garden Homes subdivision and at the University Avenue/Midvale Boulevard intersection.

1.03 PURPOSE AND NEED

A. Purpose

The proposed stormwater relief culvert is the recommended alternative of a stormwater management study completed for the Village of Shorewood Hills and City of Madison in 1997. The purpose of the study included:



Source: USGS Madison West, WI Topographic Quadrangle
(7.5 Minute Series)
Scale: 1" = 2000'

Figure No. 1.01-1 258-761	Village of Shorewood Hills University Avenue / Midvale Boulevard Environmental Report General Location Map	STRAND ASSOCIATES, INC.

1. Identification of physical characteristics of the tributary area that impact stormwater runoff amounts and depths to the University Avenue/Midvale Boulevard intersection.

2. Evaluation of the adequacy of the existing box culvert systems serving the University Avenue/Midvale Boulevard intersection to convey stormwater discharges.

3. The formulation of alternatives for alleviating existing flooding problems in the study area.

4. Recommendation of the most cost-effective alternative to alleviate existing flooding problems in the study area for a 100-year storm.

The study is included in Appendix A of this report.

The purpose of the proposed culvert is to provide flood relief for stormwater volume exceeding the capacity of the existing drainage system.

B. Need

Flooding near the University Avenue/Midvale Boulevard intersection has been a concern of both the City of Madison and Village of Shorewood Hills for over 50 years. The site is a natural depression, a former landfill, and has no overland flow route to provide drainage relief. Public records indicate severe flooding has occurred on numerous occasions, with damages impacting single family homes and commercial lots. In addition, recurrent flooding has resulted in closure of both University Avenue, a major east-west arterial street, and Midvale Boulevard, a major north-south arterial street. Several studies have been undertaken in the past by the City of Madison and the Village of Shorewood Hills, but no action was taken to remedy the situation.

Most recently, severe flooding affected the area on June 16-17, 1996, and on several occasions in the summer of 2000. During the storm of June 16-17, 1996, the University Avenue/Midvale Boulevard intersection was flooded with depths of up to 3 feet. The Kohl's parking lot experienced depths of 4 feet or more. Widespread basement and surface flooding occurred in the Garden Homes subdivision.

Intersection flooding occurred on at least three occasions between May and August of 2000. The most severe flood occurred on the evening of June 1, 2000. During this event, the University Avenue intersections with Midvale Boulevard and Shorewood Boulevard became impassable. The University Avenue intersections with University Bay Drive and Highland Avenue, located closer to Willow Creek, also had nearly 12 inches of standing water. Locust Drive, an east-west street between Shorewood Boulevard and Garden Homes, had 8 to 10 inches of standing water. Most of the homes in the Garden Homes subdivision were affected either by basement backups or surface overflows. The basement of Janet's Antiques, in the Kohl's Shopping Center, collapsed.

1.04 AUTHORITIES AND APPROVALS

The following approvals may be required for this project:

1. U.S. Army Corps of Engineers approval will be required if outfall construction affects the bed of Lake Mendota.

2. A Chapter 30 permit will be required from the Wisconsin Department of Natural Resources authorizing construction.

3. Approval of the erosion and sediment control plan will be required from Dane County.

1.05 ESTIMATED COST AND FUNDING SOURCE

The Opinion of Probable Cost for the project is approximately $7,000,000, based on the 1997 report. A cost share agreement is being negotiated between the City of Madison and the Village of Shorewood Hills. It is anticipated that the City of Madison will fund 60 to 70 percent of the project, and the Village of Shorewood Hills will fund the remaining 30 to 40 percent. The Village's share will be from revenue generated by the Kohl's Shopping Center Tax Incremental Financing (TIF) district.

SECTION 2
PROPOSED PHYSICAL CHANGES

2.01 MANIPULATION OF TERRESTRIAL RESOURCES

A conceptual plan view of the proposed relief culvert is shown in Figure 2.01-1. A profile view is shown in Figure 2.01-2. The relief culvert will include the following elements:

1. A junction chamber located in a grassed median at the low point of the Kohl's Shopping Center. The chamber will be located approximately 180 feet north of University Avenue and 20 feet west of Rose Place. The junction chamber will connect to the existing 12-foot by 5-foot box culvert to a proposed 11-foot by 6-foot box culvert through the Kohl's Shopping Center parking lot. A weir will be constructed within the junction chamber to prevent overflow from the existing box culvert from entering the relief culvert until the capacity of the existing box culvert is maximized. An open grate will be constructed on top of the junction chamber to allow excess surface overflows to enter the junction chamber, overtop the weir (if the flow is large enough), and to enter the relief culvert. Shallow depth flows (less than approximately 3 inches) will drain to the existing box culvert through parking lot inlets.

   Construction of the junction chamber will disturb approximately 1,650 square feet. It is anticipated that this disturbance will occur concurrently with the planned Kohl's Shopping Center renovation.

2. A new 11-foot by 6-foot box culvert draining northerly from the junction chamber to near the Locust Drive right of way. This section of the culvert will be constructed by placement of the new culvert in an open trench. The culvert is planned for construction as part of the Kohl's Shopping Center redevelopment project.

   Construction of the box culvert will disturb approximately 6,600 square feet. It is anticipated that this disturbance will occur concurrently with the planned Kohl's Shopping Center renovation.

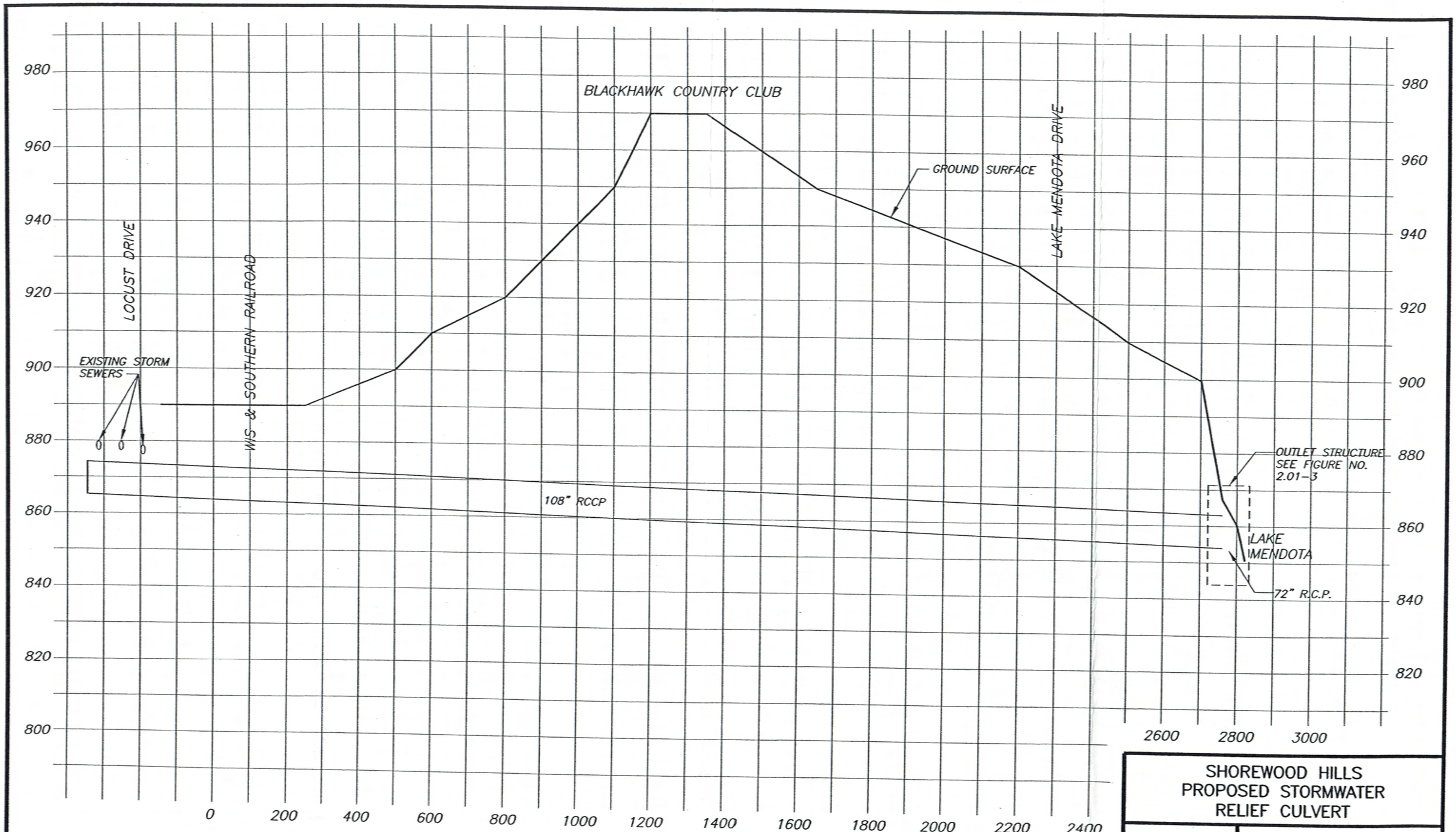
3. A new circular culvert, 108 inches in diameter, constructed from the Locust Drive right-of-way to a junction chamber located at the Village of Shorewood Hills Marina. It is anticipated that tunneling operations will be by "single pass" technology. This will require one pit at the upstream end for the boring equipment to operate and one smaller pit at the downstream end to remove equipment. No disturbances to the ground between the upstream and downstream pits are anticipated.

   Construction of the 108-inch culvert will require removal of approximately 10,000 cubic yards of material. The primary disturbance will be at the staging area and at the outlet at the marina. It is anticipated that the staging area will impact approximately a 20,000 square foot area. Boring equipment will operate from this location, materials will be stored, and material removed during tunneling operations will be loaded on trucks and hauled away. This disturbance will be temporary, and the area will be restored after construction operations are completed.

PROPOSED CULVERT ROUTE
ENVIRONMENTAL REPORT
SHOREWOOD HILLS, WI

STRAND ASSOCIATES, INC. ENGINEERS

FIGURE NO.



NOTE: CITY OF MADISON DATUM + 845.6 = USGS DATUM

SOURCE: GROUND ELEVATIONS BASED ON MADISON WEST TOPOGRAPHIC QUADRANGLE (USGS-1983)

SHOREWOOD HILLS
PROPOSED STORMWATER
RELIEF CULVERT

STRAND ASSOCIATES, INC. ENGINEERS
910 WEST WINGRA DRIVE
MADISON, WISCONSIN 53715
(608) 251-4843

FIGURE NO. 2.01-2
PRELIMINARY
CULVERT
PROFILE

258-806

File: S:\@Sa\251--300\258\806\Acad\proposed\Stormwtr-Reulvert.dwg
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4. An outlet structure, consisting of a junction chamber, energy dissipation/sedimentation structure, and culvert pipe leading from the junction chamber to the energy dissipation structure. Conceptual outlet structure plans are shown in Figures 2.01-3 and 2.01-4. This plan includes constructing a large underground chamber with a sediment sump to receive flow from the tunneled portion of the culvert. The chamber would be connected to a 72-inch culvert discharging to a sedimentation/energy dissipation structure. The 72-inch culvert would reduce the velocities of the stormwater coming out of the 108-inch culvert. Flows in excess of the 50-year storm would surcharge the 72-inch culvert and flow overland along a stabilized overland flow path from the junction chamber to the lake.

   The sedimentation basin/energy dissipater would include a 4- to 5-foot-high wall to intercept flow prior to discharging to the lake. Low flows will be impounded in the basin and drain by seepage through the wall. The wall may be constructed of gabions to allow slow seepage through the stone. The use of gabions, however, will depend on their ability to withstand expected high velocities from the storm sewer. High flows will overtop the wall and drain to the lake.

2.02 MANIPULATION OF AQUATIC RESOURCES

The project will not involve construction within natural watercourses, lakes, or navigable waters. However, the project will impact drainage patterns to Lake Mendota for large storm events. Currently, stormwater runoff from the 1,952-acre tributary area drains through an existing box culvert owned by the City of Madison to an outfall at Willow Creek (Figure 2.02-1). For large storm events, stormwater volumes exceeding the capacity of the existing box culvert are temporarily stored in the depressional area near the University Avenue/Midvale Boulevard intersection before draining to Willow Creek.

After construction of the proposed project, small storm events will continue to drain through the existing box culvert, discharging to the Willow Creek outfall. For large storm events, excess stormwater runoff that is currently impounded near the intersection will enter the new relief culvert and discharge to Lake Mendota at the Shorewood Hills Marina. Discharge through the new relief culvert is expected to be short in duration (less than two hours) and relatively infrequent. Hydraulic modeling results indicate that stormwater will drain through the culvert for events having a 20 percent chance of occurring in a given year (a "5-year" storm event).

2.03 BUILDINGS, TREATMENT UNITS, ROADS, AND OTHER STRUCTURES

There are no new buildings or roads proposed as part of this project. Stormwater treatment units include the proposed energy dissipation/sedimentation structure described in Section 2.01.

2.04 EMISSIONS AND OTHER DISCHARGES

As discussed in Section 2.02, the project will result in stormwater discharge to Lake Mendota at

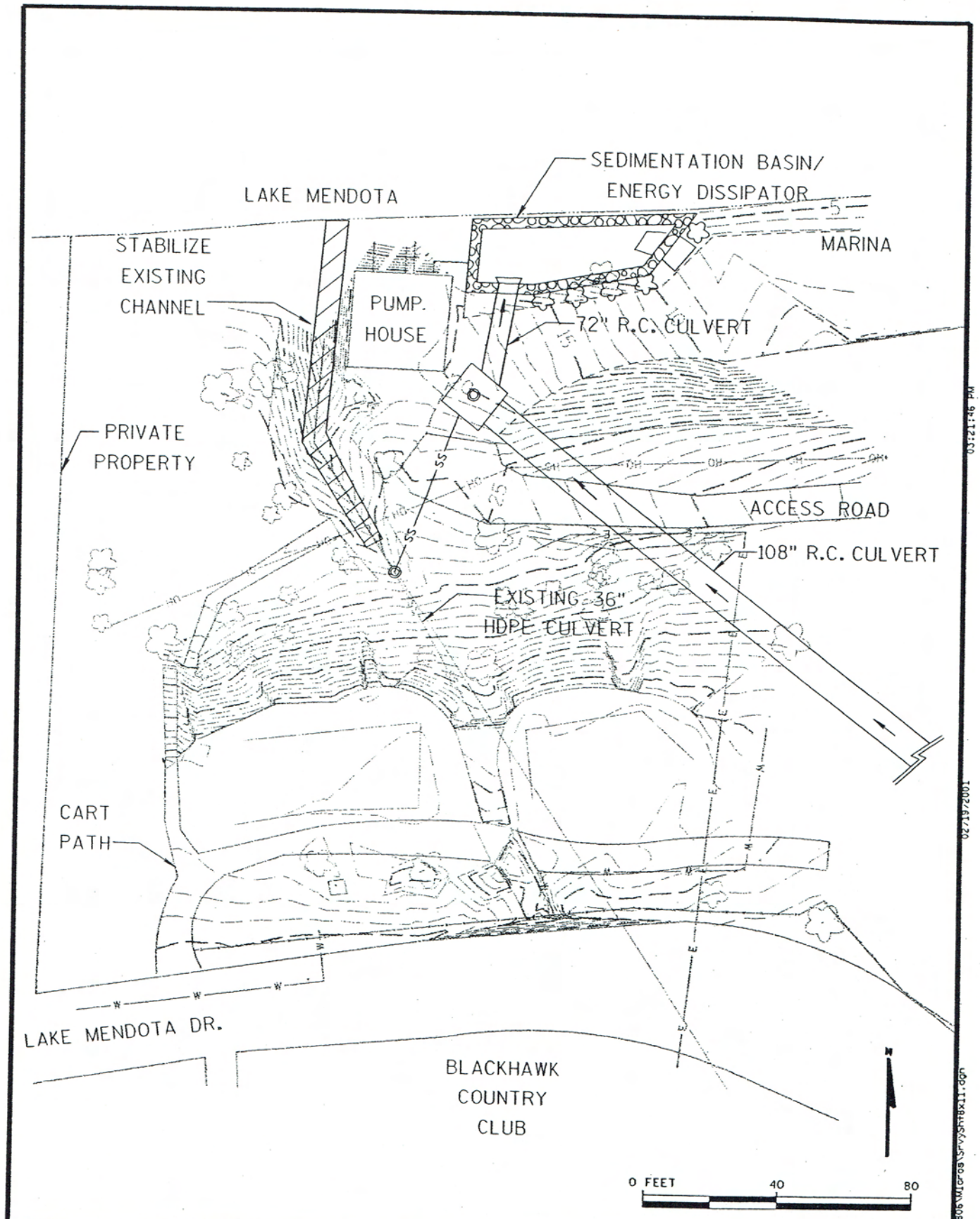

FIGURE 2.01-3 258-806	VILLAGE OF SHOREWOOD HILLS RELIEF CULVERT CONCEPTUAL OUTFALL DETAIL	STRAND ASSOCIATES, INC. ENGINEERS 910 WEST WINGRA DRIVE MADISON, WISCONSIN 53715 (608) 251-4843

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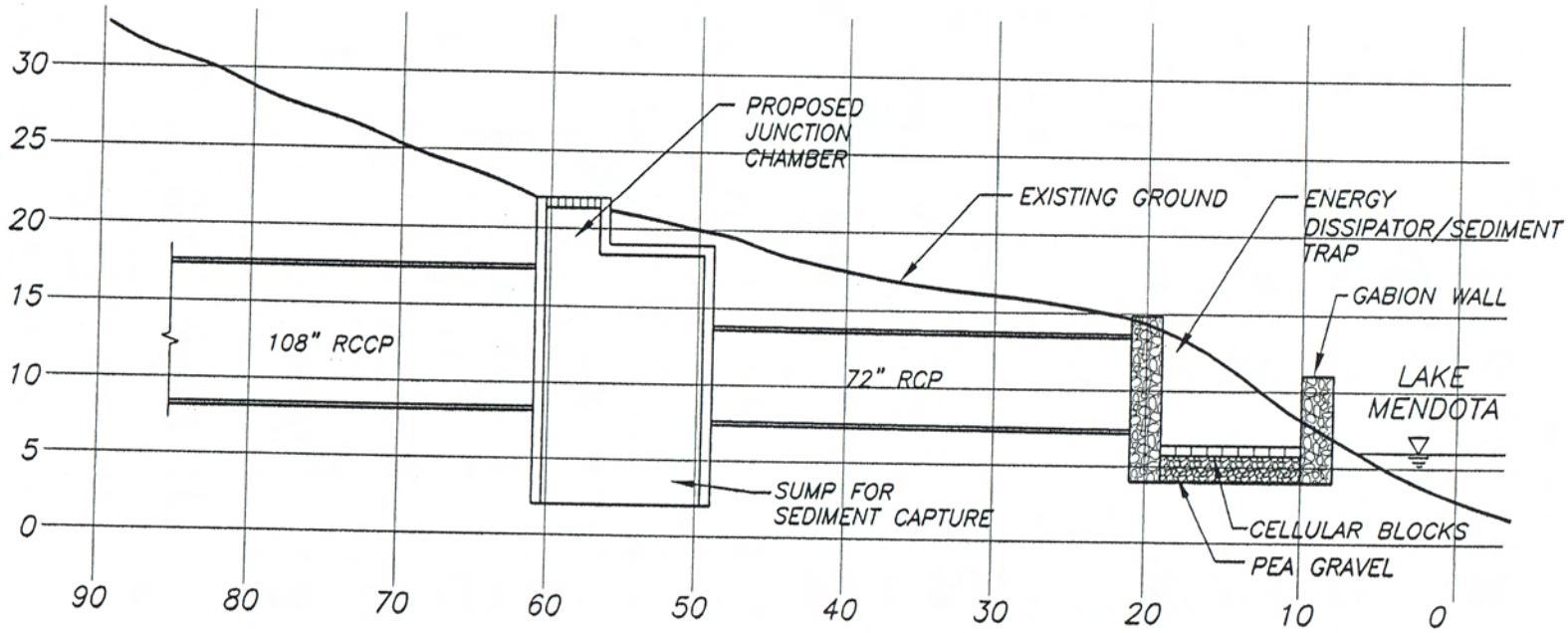

SHOREWOOD HILLS
PROPOSED STORMWATER
RELIEF CULVERT

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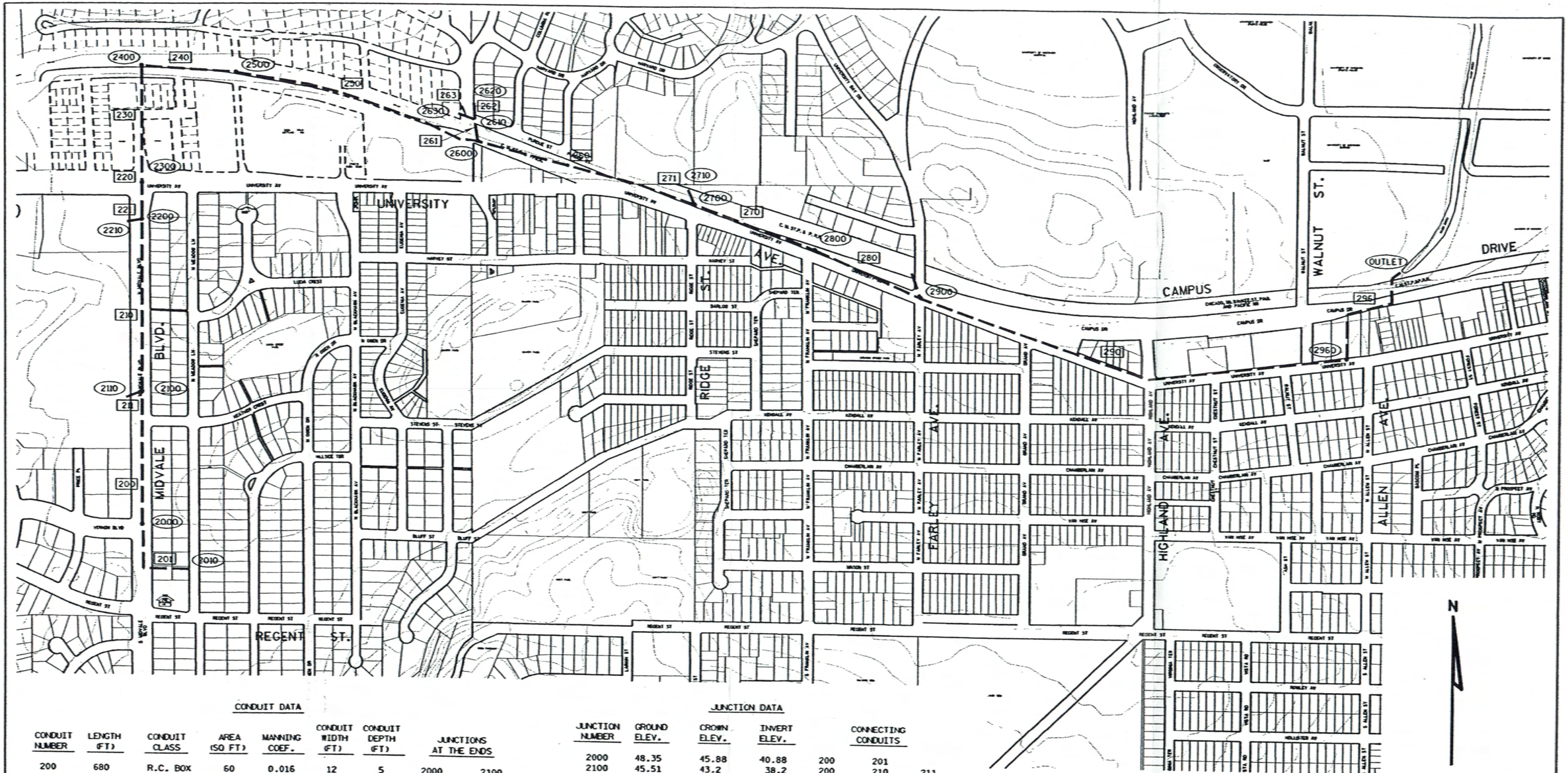
FIGURE NO. 2.01-4

CONCEPTUAL
OUTFALL PROFILE

258-806



CONDUIT DATA

CONDUIT NUMBER	LENGTH (FT)	CONDUIT CLASS	AREA (SQ FT)	MANNING COEF.	CONDUIT WIDTH (FT)	CONDUIT DEPTH (FT)	JUNCTIONS AT THE ENDS	
200	680	R.C. BOX	60	0.016	12	5	2000	2100
210	1190	R.C. BOX	60	0.016	12	5	2100	2200
220	240	R.C. BOX	60	0.016	12	5	2200	2300
230	640	R.C. BOX	60	0.016	12	5	2300	2400
240	630	R.C. BOX	60	0.016	12	5	2400	2500
250	1440	R.C. BOX	60	0.016	12	5	2500	2600
260	1420	R.C. BOX	75	0.016	15	5	2600	2700
270	770	R.C. BOX	90	0.016	15	6	2700	2800
280	700	R.C. BOX	90	0.016	15	6	2800	2900
290	2530	R.C. BOX	72	0.016	12	6	2900	2960
296	750	R.C. BOX	54	0.016	12	4.5	2960	OUTLET
221	100	R.C. PIPE	4.91	0.016	2.5	2.5	2210	2200
211	100	R.C. PIPE	4.91	0.016	2.5	2.5	2110	2100
201	330	R.C. PIPE	4.91	0.016	2.5	2.5	2010	2000
261	80	R.C. BOX	25	0.016	5	5	2610	2600
262	100	R.C. PIPE	9.62	0.016	3.5	3.5	2620	2610
263	100	R.C. PIPE	9.62	0.016	3.5	3.5	2630	2610
271	100	R.C. PIPE	9.62	0.016	3.5	3.5	2710	2700
291	150	R.C. PIPE	0.79	0.016	1	1	2910	2900

JUNCTION DATA

JUNCTION NUMBER	GROUND ELEV.	CROWN ELEV.	INVERT ELEV.	CONNECTING CONDUITS		
2000	48.35	45.88	40.88	200	201	
2100	45.51	43.2	38.2	200	210	211
2200	40.25	38.13	33.13	210	220	221
2300	39.66	36.63	31.63	220	230	
2400	38.67	32.74	27.74	230	240	
2500	42.45	32.73	27.73	240	250	
2600	36.68	30.55	25.55	250	260	261
2700	34.49	29.83	23.83	260	270	271
2800	30.85	28.6	22.6	270	280	
2900	31.03	27.73	21.73	280	290	291
2960	27.18	19.05	13.05	290	296	
OUTLET	12.28	5.7	1.2	296		
2210	45	37.5	35	221		
2110	48.5	41.5	39	211		
2010	50	44.78	42.28	201		
2610	36	35	30	261	262	263
2620	35	34.5	31	262		
2630	36	34.5	31	263		
2710	33.5	32	28.5	271		
2910	31.5	29	28	291		

LEGEND

EXISTING BOX CULVERT

SWMM CONDUIT NUMBER 201

SWMM JUNCTION NUMBER 2000

VILLAGE OF SHOREWOOD HILLS
ENVIRONMENTAL REPORT
MIDVALE BLVD. / UNIVERSITY AVENUE

STRAND ASSOCIATES, INC. ENGINEERS

FIGURE NO.
2.02-1

EXISTING DRAINAGE SYSTEM

the Shorewood Hills Marina. This is expected to occur on an infrequent basis and over a short duration each occurrence (less than two hours).

Average Annual Stormwater volumes and pollutant loadings to Willow Creek and the University Avenue/Midvale Boulevard intersection were estimated using the SLAMM computer program by the City of Madison as part of their stormwater permit application. Estimated pollutant loadings are summarized in Table 2.04-1.

Location	Runoff Volume (cubic feet/yr)	Particulate Solids (lbs/yr)	Filterable Solids (lbs/yr)	Particulate Phosphorus (lbs/yr)	Filterable Phosphorus (lbs/yr)	Total Copper (lbs/yr)
University Avenue/Midvale Boulevard	39,314,030	438,982	948,750	968	560	539
Willow Creek	50,437,533	564,133	1,201,275	1,221	698	702

Table 2.04-1 Estimated Pollutant Loadings (SLAMM)

According to Table 2.04-1, approximately 1,158 acre-feet (50,437,533 cubic feet) of stormwater drains to Lake Mendota at the Willow Creek outfall per year, including approximately 282 tons (564,133 pounds) of particulate solids. Under current conditions, all of this sediment discharges to the Willow Creek outfall.

Stormwater volumes for single storm events, including the 10-year, 50-year, and 100-year frequency, 1-hour duration storms, were evaluated using the XP-SWMM computer program. Stormwater runoff volumes for single storm events were estimated for the entire watershed, the Willow Creek outfall, and the proposed marina outfall with and without the relief culvert in place. Results are summarized in Table 2.04-2.

	10-Year Storm (ac-ft)		50-Year Storm (ac-ft)		100-Year Storm (ac-ft)	
Location	No Culvert	With Culvert	No Culvert	With Culvert	No Culvert	With Culvert
Existing Willow Creek Outfall	135	123	281	197	369	242
Proposed Marina Outfall	0	12	0	84	0	127
Total Watershed	135	135	281	281	369	242

Table 2.04-2 Runoff Volumes for Single Storm Events

As indicated in Table 2.04-2, the volume of stormwater runoff to the proposed outfall will vary from approximately 12 acre-feet for a 10-year, 1-hour storm event, to 127 acre-feet for a 100-year, 1-hour storm event. Storm events less than approximately a 5-year frequency will drain to Willow Creek and will not impact the marina outfall.

Table 2.04-3 compares the stormwater volume draining to the marina outfall with the typical total annual runoff volume from the watershed, based on the city's SLAMM model.

	10-Year Storm		50-Year Storm		100-Year Storm	
Annual Runoff Volume (ac-ft)	Volume (ac-ft)	% of Annual Watershed Volume	Volume (ac-ft)	% of Annual Watershed Volume	Volume (ac-ft)	% of Annual Watershed Volume)
1158	12	1.04%	84	7.25%	127	10.97%

Table 2.04-3 Runoff Volume to Marina as a Percentage of Annual Runoff Volume

Table 2.04-3 indicates that the estimated runoff volume from a single 10-year, 1-hour storm event to the proposed outfall would be approximately 1 percent of the total annual expected runoff volume from the watershed. The estimated runoff volume from a single 100-year, 1-hour storm event would be approximately 11 percent of the total typical annual expected runoff volume from the watershed.

After construction of the relief culvert, the amount of material deposited at the marina will vary from year to year, depending on weather. During a "typical" or dry year, there will be little, if any, deposition at the marina since most discharge will continue through the existing culvert to Willow Creek. If a single 10-year storm occurs in a given year, modeling indicates that the relief culvert will carry approximately 12 acre-feet of stormwater volume. This represents approximately 1 percent of the annual volume to the intersection. It is anticipated that the proportion of particulate solids and other pollutants would be low since the first flush will be directed to Willow Creek. Many of the particulates directed through the relief culvert would be captured in the proposed sedimentation basin.

During a 100-year storm event, approximately 127 acre-feet of stormwater will drain through the relief culvert, according to modeling results. While this is a large volume of runoff, it represents only approximately 11 percent of the typical annual runoff volume to the intersection. Relating sediment loading to runoff volume, the amount of sediment drained to the outfall during a 100-year storm event is small in comparison with the average annual volume to the intersection. Again, it is anticipated that the proportion of particulate solids and other pollutants in the relief culvert will be relatively low since the first flush will be directed to Willow Creek.

SECTION 3
AFFECTED ENVIRONMENT

3.01 GENERAL

This section describes the physical, biological, and cultural resources potentially impacted by the proposed project. Data upon which information in this section is based includes:

1. The 1997 Strand Associates report titled Stormwater Management Study – University Avenue/Midvale Boulevard Area.

2. Results of a dive survey of the Shorewood Hills Marina area by Kurt Welke, DNR Fisheries Biologist

3. Field inspection.

4. Soil borings.

3.02 PHYSICAL ENVIRONMENT

A topographic map of the contributing watershed is shown in Figure 3.02-1. This watershed includes approximately 1,952 acres to the outlet at Willow Creek with 1,180 acres of it directly tributary to the University Avenue/Midvale Boulevard intersection. The overall land use in the watershed is approximately 65 percent low to high density residential, 23 percent commercial development, and 12 percent open space. Appendix A provides physical and hydrologic information about the watershed.

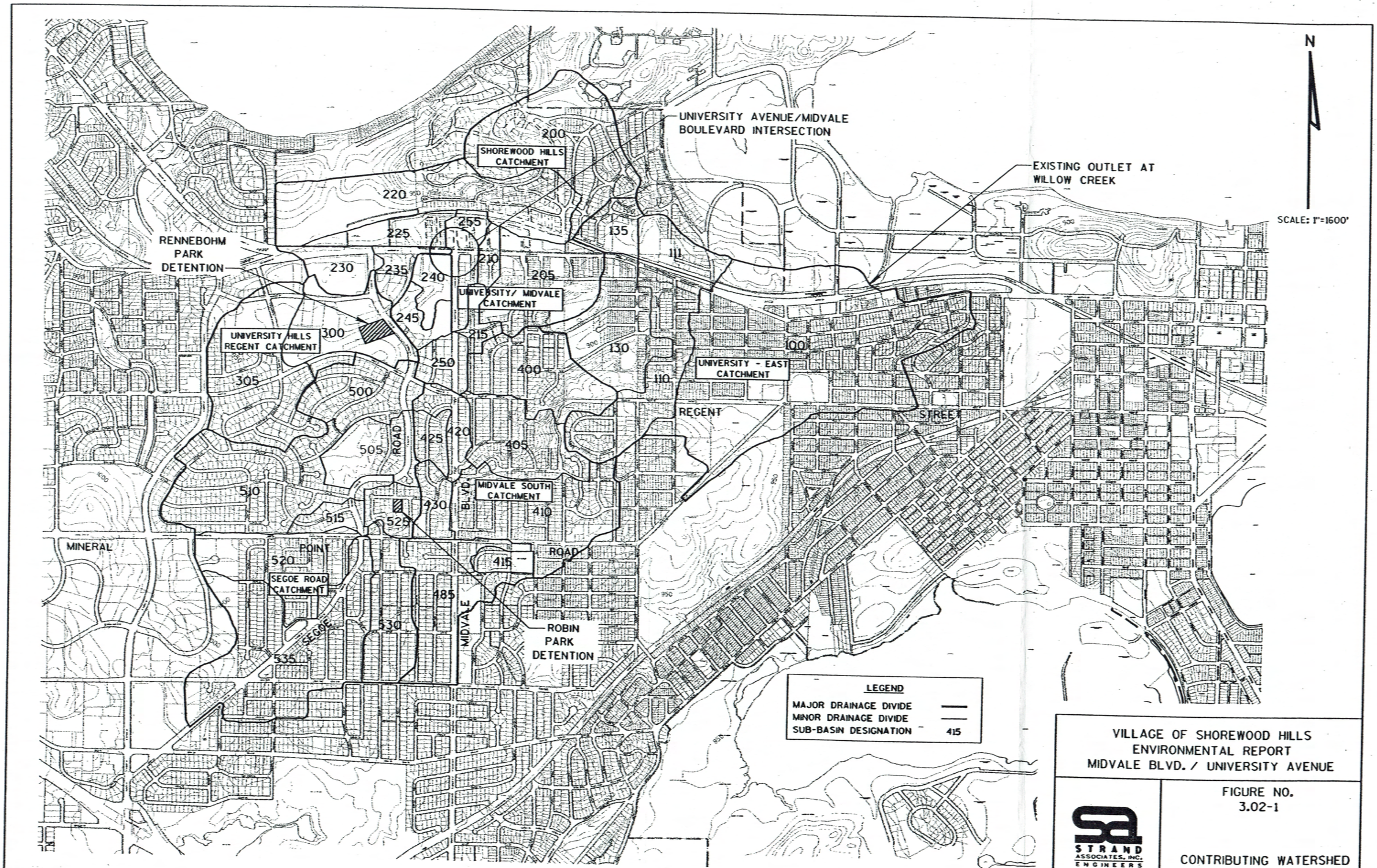
The terrain near the upstream end of the proposed relief culvert at the University Avenue/Midvale Boulevard intersection culvert is flat. The golf course consists of rolling hills.

Soil borings (Appendix C) taken in the golf course indicate sandstone of the Franconia formation. Further investigation is needed to accurately determine the elevation of groundwater.

3.03 BIOLOGICAL RESOURCES

As the project area is developed, no rare or endangered terrestrial biological resources are believed to be present that will be affected by the project. Terrestrial impacts should be limited to the area near the Kohl's Shopping Center and marina area and are expected to primarily occur during the construction period.

The primary aquatic resource potentially affected by the project is the Lake Mendota shoreline in the vicinity of the Shorewood Hills Marina. An underwater survey of the shoreline area was conducted by Kurt Welke, DNR fisheries biologist, on August 22, 2000. Results of the survey indicated that aquatic vegetation within 300 feet of the lakeshore consists of dense Vallisinaria beds, fair amounts of milfoil, and small amounts of coontail. Fish observed include walleye, smallmouth bass, carp, and black crappie. Substrates along the shoreline ranged from clean sand to a flocculent coarse silt overlying gravel. Outlying portions of the transects sampled



VILLAGE OF SHOREWOOD HILLS
ENVIRONMENTAL REPORT
MIDVALE BLVD. / UNIVERSITY AVENUE

FIGURE NO.
3.02-1

CONTRIBUTING WATERSHED

included a marl-type bottom. Results indicated that the habitat is typical of other shoreline areas along the lake. No endangered species or habitat were identified.

3.04 CULTURAL RESOURCES

A. Land Use

Land use at the upstream end of the proposed culvert is commercial, including the Kohl's Shopping Center. Garden Homes, a residential subdivision, is located immediately west of the shopping center. The majority of the proposed culvert will be located under the Blackhawk Golf Course at depths ranging from 20 to 100 feet. The golf course is owned by the Village of Shorewood Hills. Depending on the final location of the headworks, a short portion of the culvert may be located under private residences. Appropriate easements will be required for this work. The proposed culvert will outlet at the Shorewood Hills Marina, owned by the Village of Shorewood Hills. Land use east and west of the marina is residential. The golf course is located south of the marina.

B. Archaeological

Indian burial mounds are interspersed throughout the Blackhawk Golf Course. These burial mounds are at significantly shallower depths than the proposed depth of the relief tunnel and should not be affected by the proposed project.

SECTION 4
ENVIRONMENTAL CONSEQUENCES

4.01 PHYSICAL CONSEQUENCES

A. Beneficial Impacts

1. The project will greatly reduce the risk of flooding of the University Avenue intersections at Midvale Boulevard, Shorewood Boulevard, University Bay Drive, and Highland Avenue. Flooding will also decrease on Locust Drive. This will reduce financial impacts to Garden Homes residents resulting from repeated damages caused by flooding. Also, the project will reduce physical hazards associated with flooding to Garden Homes residents and, in general, improve the quality of life for area residents.

2. The project will reduce the frequency of closure of the University Avenue/Midvale Boulevard intersection. The University Avenue/Midvale Boulevard intersection is among the busiest intersections in the City of Madison, based on traffic volumes. According to 1999 data, University Avenue carries 45,000 to 50,000 vehicles per day, and Midvale Avenue carries over 20,000 vehicles per day. University Avenue is a primary route for emergency vehicles to the west side of Madison, and for outlying areas to the west. Closure of the intersection can result in substantial increases in response times.

   Wisconsin Department of Transportation standards recommend that a major urban arterial road remain passable for emergency vehicles during a 50-year storm event. This means that the annual probability of road closure because of flooding should not be greater than 1 in 50, or 2 percent. According to computer modeling and historical observation, the annual probability of road closure due to flooding is presently between 10 and 20 percent. A primary benefit of the project is that it will bring the intersection into compliance with recommended standards and reduces the risk of closure during major storm events.

B. Adverse Impacts

1. During major storm events, the proposed culvert will direct a substantial amount of stormwater runoff to the new outlet at the marina. Stormwater runoff may include sediment and other nonpoint source pollutants. The project will not increase the volume of stormwater or amount of pollutant loading to Lake Mendota, as a whole. However, the project will redirect a portion of the flow currently draining to the Willow Creek outfall to the marina. This may cause localized sedimentation near the marina.

2. The new outfall will be above the water surface. While landscaping and other measures will hide the outfall from lakeshore residences and marina users, it will be visible from the lake.

3. The project will take approximately eight months to construct. During this period, construction activities will disrupt traffic, create noise, and displace sediment near the Garden Homes subdivision, Kohl's Shopping Center, and the marina. While measures

will be incorporated to minimize construction-related impacts, some disruptions are unavoidable.

4.02 BIOLOGICAL CONSEQUENCES

A. Beneficial Impacts

Construction of the relief culvert alone will not provide biological benefits to Lake Mendota. Construction of an energy dissipation structure and restoration of the shoreline near the Shorewood Hills Marina may reduce shoreline sedimentation resulting from small to moderate storm events.

B. Adverse Impacts

Construction of the project, particularly construction activities near the marina, will displace soil, possibly resulting in localized sedimentation of the shoreline area. Erosion and sediment control measures during construction will be incorporated to minimize soil loss. However, because of the proximity to the outfall, some soil loss will be unavoidable. Postconstruction sedimentation may also occur near the outfall following major storm events.

4.03 CULTURAL CONSEQUENCES

A. Land Use Impacts

Long-term benefits to residents in the Garden Homes Subdivision will be significant as the relief culvert should minimize future flood-related property damage. The culvert will reduce the closure incidence of the University Avenue/Midvale Boulevard and University Avenue/Shorewood Boulevard intersections. Property damage and flooding on Locust Drive and at the shopping area north of the intersection should also be alleviated as a result of the relief culvert.

Temporary disturbances to land use will be incurred on Locust Drive, the golf course, and the marina during construction of the relief culvert.

B. Social/Economic Impacts

The primary social/economic benefit may be an increase in property values in the Garden Homes area if the risk of property damage caused by flooding is reduced. No adverse social/economic impacts are anticipated as a result of the project.

C. Archaeological/Historical Impacts

The only archaeological/historical features noted in the project area are Indian Burial Mounds located throughout the Blackhawk Golf Course. No adverse impacts are anticipated to these features because the relief culvert will be located at least 20 feet below them.

SECTION 5
ALTERNATIVES

5.01 GENERAL

To evaluate the most cost-effective stormwater management plan, 14 combinations of various alternatives were considered. Alternatives considered included stormwater detention, improved stormwater conveyance from the intersection, and floodproofing. These alternatives are discussed in detail in Appendix A. A summary of various alternatives considered is provided in this section.

5.02 NO ACTION

If no action is taken at this location, flooding will continue to pose safety and damage risks to properties around the University Avenue/Midvale Boulevard intersection. As development continues in the western portions of Madison, the University Avenue/Midvale Boulevard intersection will serve an increasingly important role as an emergency access route. No action will increase the likelihood of delays in response time for emergency vehicles on University Avenue during flood events.

5.03 STORMWATER DETENTION

Due to the developed nature of the contributing area, opportunities for stormwater detention or infiltration are limited. Three possible locations considered included Rennebohm Park, Lucia Crest Park, and underground at the Kohl's Shopping Center. Each location is discussed below.

A. Rennebohm Park

Rennebohm Park is located west of Segoe Road and south of Regent Street. Open space remains in the park adequate for an additional 15 to 20 acre-feet of storage. Hydrologic modeling indicates that because only a portion of the tributary area to Rennebohm Park could be controlled, a detention basin at this location alone would not resolve flooding problems at the University Avenue/Midvale Boulevard area. However, construction of an additional basin could reduce pollutant loading from this area and may be beneficial if incorporated into an overall basinwide plan for reducing stormwater discharges.

B. Lucia Crest Park Detention Basin

Lucia Crest Park is located in a natural depression, one block east of Midvale Boulevard and one block south of University Avenue. It may be possible to develop the park site as an off-line, dry detention basin with a storage capacity of 20 acre-feet. This would require sufficient inlet capacity, construction of a control structure, a mechanism to drain the basin back into the Midvale Boulevard storm sewer system, and dry weather improvements to make the park more acceptable to affected residents. Hydrologic modeling indicates that this detention basin alone would not resolve flooding problems at the University Avenue/Midvale Boulevard area. Also, residents adjacent to the park may have strong objections to this alternative.

C. Stormwater Detention Chamber at Kohl's Parking Lot

The possibility of constructing an underground storage chamber under the Kohl's Shopping Center Parking Lot was investigated. Hydrologic modeling results indicated that to accommodate the excess stormwater volume, a chamber having a storage volume of over 70 acre-feet would be needed. A pumping station would be necessary to drain the chamber and keep it dry between storm events. Construction of such a chamber would be cost prohibitive.

5.04 STORMWATER CONVEYANCE

Consideration was given to construction of a new 12 feet wide by 6 foot wide box culvert parallel to the existing box culvert easterly to the existing outfall at Willow Creek. Conflicts to existing utilities, disruption to traffic, construction under existing pavement, and coordination with the railroad make this alternative impractical and cost prohibitive.

5.05 FLOODPROOFING

The least expensive alternative to protect the Garden Homes subdivision from flooding during the 100-year event would be floodproofing. One method of floodproofing would be to construct a berm or wall/berm combination to prevent impounded water from the intersection from backing into the subdivision. Measures would also be necessary to intercept, store, and convey stormwater runoff from areas west of the subdivision to the existing box culvert.

Floodproofing the Garden Homes subdivision would not reduce the depth or frequency of flooding of the University Avenue/Midvale Boulevard intersection or the Kohl's Shopping Center parking lot. Floodproofing may, in fact, aggravate flooding for areas to the east because excess stormwater runoff currently impounded in the subdivision would be displaced by the flood mitigation measures. For this reason, floodproofing alone is not considered the most effective alternative.

SECTION 6
EVALUATION OF PROJECT SIGNIFICANCE

6.01 SIGNIFICANCE OF ENVIRONMENTAL EFFECTS

There has been growing awareness of the impact of development in the Madison area on lake water quality and lake levels. Increasing imperviousness within the Yahara Lakes watershed has led to increasing incidents of beach closures, algae growth, and other nuisance-related water quality issues. Watershed-based best management practices encouraging treatment or infiltration of stormwater runoff prior to or in lieu of direct discharge to the Yahara Lakes has been strongly encouraged. Such measures are intended to filter sediment and other pollutants and provide groundwater recharge.

While we concur that these issues must be addressed throughout the Yahara Lakes watershed, we do not believe the proposed relief culvert will have significant environmental effects. This is due to the following:

1. The project will not alter the hydrologic characteristics of the watershed. The cumulative volume of stormwater runoff to Lake Mendota will not be affected by the project. The project will redirect existing culvert overflows to a new discharge point. However, the net stormwater volume to Lake Mendota will remain the same as predeveloped conditions.

2. For postconstruction conditions, the project will not increase the amount of sediment or other pollutants discharged to Lake Mendota. The project will redirect the discharge point for culvert overflows from Willow Creek to the marina. This will create a risk of increased localized sedimentation near the marina. However, the cumulative impact on the lake is expected to be negligible. The junction chamber will be designed to direct the most sediment-laden "first flush" to the Willow Creek outfall to minimize sediment carried to the new outfall. The relief culvert will be designed so that it will carry stormwater on an infrequent basis. Measures will be incorporated to trap sediment at the proposed outfall prior to discharge to the lake.

3. The alternatives analysis performed for this report concluded that best management practices such as infiltration and other source controls alone would not alleviate flooding conditions near the University Avenue/Midvale Boulevard intersection. There is not adequate open space available in the watershed to accommodate the necessary stormwater detention or infiltration volume.

   While such controls should be encouraged and may provide incremental water quality benefits, they will not alone significantly reduce downstream flooding.

6.02 POSSIBLE SUPPLEMENTAL ACTIONS

Several additional alternatives could supplement the stormwater relief culvert to reduce both the volume and sediment content of the stormwater runoff reaching the University Avenue/Midvale Boulevard intersection. One possible supplemental action is to improve infiltration-enhancing features upstream of the intersection. This would require cooperation between the University, City, and County to effectively implement sediment reduction measures at residential,

commercial, and public properties within the watershed. Another possibility is detention and infiltration on the Blackhawk Golf Course near the tunnel inlet and at Rennebohm Park, as mentioned in the report. Lastly, use of a sedimentation structure at Willow Creek could settle out large amounts of sediment in the stormwater draining into Lake Mendota.

6.03 RISKS

The primary environmental risk associated with the proposed culvert is that it would provide a new conduit for direct discharge into Lake Mendota in case of an accidental spill. Two measures will be incorporated to minimize the risk of such an occurrence:

1. The junction chamber is designed with a weir to direct the first flush to the existing Willow Creek outfall. While this will not reduce the risk of spills, it will lengthen the route to the lake and provide a greater opportunity for treatment.

2. The proposed overflow grate is being placed in a grassed median. The median will have a curb approximately 3 inches high around its perimeter. This curb will cause low flows to drain to parking lot inlets that will be connected to the existing culvert. Flood depths will have to reach at least 3 inches in the parking lot before flowing through the overflow grate into the junction chamber. Once inside the junction chamber, the stormwater would only enter the relief culvert after overtopping a weir. The weir will not be overtopped until the full capacity of the existing culvert is utilized.

Another environmental risk is sediment loss to Lake Mendota during outfall construction at the marina. Best Management Practices will be incorporated and enforced during the construction period so that soil loss rates do not exceed 7.5 tons per acre, in accordance with the Dane County Erosion and Sediment Control Ordinance. However, failure by the contractor to maintain measures in accordance with specifications or the occurrence of an exceptional rainstorm after topsoil has been removed could significantly increase soil loss rates. A possible means of reducing this risk is construction of a permanent sedimentation feature prior to large-scale earth disturbance upstream from the outfall.

6.04 SIGNIFICANCE OF PRECEDENT

Construction of new storm sewer outfalls to navigable waters is a common practice, and with precedent. Based upon our interpretation of Chapter 30 of the Wisconsin State Statutes, construction of a new storm sewer outfall is prohibited without a permit if placed on the bed of Lake Mendota, a navigable stream. The proposed outfall will be constructed above the ordinary high water mark of Lake Mendota. Therefore, construction of the new culvert and junction chamber should not require permitting by the DNR if completed above the ordinary high water mark of the lake.

Construction of the proposed sedimentation/energy dissipation structure may disturb an area in excess of 10,000 square feet. Therefore, this activity may require permitting by the DNR under Chapter 30 of the State Statutes. Theoretically, the outfall could be designed in a way that

would not require permitting. However, considering the size of the proposed outfall and expected interest by area residents and DNR staff, Department approval is being sought.

Based on feedback received in initial public meetings and agency meetings, some controversy is expected with this project. Organizations opposing the project may include lakefront homeowner's groups, fishing groups, and environmental organizations. Anticipated concerns include:

1. Potential degredation of lake water quality resulting from a new storm sewer outfall.

2. Potential increasing water levels because of additional stormwater runoff to the lakes.

As discussed in this report, we do not believe there is a substantial risk of water quality degradation, increasing lake levels, or other adverse environmental impacts associated with the project. However, public controversy is expected because of increased sensitivity to any issue impacting the lakes. We believe much of the controversy will stem from the perception that the outfall will change the volume or character of stormwater currently discharged to the lake or that the new outfall will be the primary discharge point from the watershed. It may be possible to address some of this controversy by educating the public about the intent of the project.

Appendix D includes papers dated September 16, 2000, and December 12, 2000, by Ken Potter of the University of Wisconsin. These papers provide an example of concerns that may be raised by this project.

SECTION 7
SUMMARY OF ISSUE IDENTIFICATION ACTIVITIES

7.01 CITIZEN AND AGENCY INVOLVEMENT ACTIVITIES

A. Agency Involvement Activities

Several meetings have been held to date with regulatory agencies and individuals to discuss the project. Dates and meeting attendees are summarized below:

Meeting Date	Agency	Individuals	Purpose
Sept. 27, 1999	Dane County Land Conservation Department of Natural Resources	Aicardo Roa Jim Bertolacini	Project Overview/Discussion
December 3, 1999	Dane County Land Conservation	Aicardo Roa	Project Overview/Discussion
January 28, 2000	Dane County Land Conservation DC Lakes and Watershed Com.	Aicardo Roa Jeremy Balousek Sue Jones	Project Overview/Discussion
July 7, 2000	Department of Natural Resources	Cami Peterson	Field Visit
August 3, 2000	Department of Natural Resources	Kurt Welke	Project Overview/Field Visit
October 19, 2000	Department of Natural Resources City of Madison DC Lakes and Watershed Com. DC Land Conservation	Ken Johnson Kurt Welke Sue Josheff Carolyn Betz Russ Anderson Mary Anne Lowndes Cami Peterson Larry Nelson Sue Jones Aicardo Roa Jeremy Balousek	Project Discussion
February 2, 2001	Department of Natural Resources DC Land Conservation City of Madison	Ken Johnson Kevin Connors Larry Nelson	Discuss Task Force/Public Input Process

B. Citizen Involvement Activities

A public informational meeting was held on December 7, 2000, to discuss the project and address public concerns. This meeting included Village of Shorewood Hills citizens and elected officials, as well as Dick Lathrop and Ken Johnson from the DNR, Kevin Connors, Dane County Land Conservationist, and Ken Potter from the University of Wisconsin.

Additional meetings are planned to discuss the tunnel issue. In addition, formation of a task force has been discussed to explore measures to address water quality issues in the tributary area.

7.02 CONTACTS

Organization	Name	Phone
Army Corps of Engineers	Bill Sandy	262-547-1876
City of Madison	Larry Nelson, City Engineer	608-267-4227
Dane County Land Conservation	Aicardo Roa Kevin Connors	608-224-3730
Dane County Lakes & Watershed Commission	Susan Jones	608-267-0118
DNR	Kurt Welke, Fisheries Biologist	608-273-5946
DNR-SCR	Cami Peterson, Water Management Specialist	608-275-3208
DNR-SCR	Russ Anderson	608-275-3467
DNR-SCR	Sue Josheff	608-275-3305
DNR Stormwater Permitting	Jim Bertalocinni	608-275-3201
Village of Shorewood Hills	Tom Popp, Village Administrator	608-267-2680

APPENDIX A
1997 STORMWATER MANAGEMENT STUDY

Report on

Shorewood Hills

Stormwater Management Study
University Avenue / Midvale Boulevard Area

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10/17/97

Prepared by:

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October 1997

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October 17, 1997

Village of Shorewood Hills
810 Shorewood Boulevard
Madison, WI 53705-2115

Attention: Mr. Tom Popp, Village Administrator

Re: Stormwater Management Study - University Avenue/Midvale Boulevard

Dear Tom:

We are pleased to submit three copies of the Stormwater Management Study for the University Avenue/Midvale Boulevard area.

The intent of this report is to analyze drainage conditions within the tributary area to the existing culvert system which serves the University Avenue/Midvale Boulevard intersection to assess the adequacy of existing stormwater facilities and evaluate future needs. This assessment includes:

1. Identification of physical characteristics of the tributary area which impact stormwater runoff amounts and depths to the University/Midvale intersection.

2. Evaluation of the adequacy of the existing box culvert system serving the University/Midvale intersection to convey stormwater discharges,

3. The formulation of alternatives for alleviating existing flooding problems in the study area.

4. Recommendation of the most cost-effective alternative for alleviating existing flooding problems in the study area.

The results of this study will serve as a guideline for Village of Shorewood Hills and City of Madison officials to evaluate how best to alleviate flooding conditions within the study area.

Should you have any questions, please call.

Sincerely,

STRAND ASSOCIATES, INC.

David K. Wolmutt

David K. Wolmutt, P.E.

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STRAND
ASSOCIATES INC

Shorewood Hills

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EXECUTIVE SUMMARY

ES.01 PURPOSE AND SCOPE OF STUDY

Flooding near the University Avenue/Midvale Boulevard intersection has been a concern of both the City of Madison and Village of Shorewood Hills for over fifty years. Public records indicate severe flooding has occurred on numerous occasions, with damages impacting single family homes and commercial lots. In addition, recurrent flooding has resulted in closure of both University Avenue, a major east-west arterial street, and Midvale Boulevard, a major north-south arterial street.

The intent of this report is to analyze drainage conditions within the area tributary to the existing culvert system which serves the University Avenue/Midvale Boulevard intersection to assess the adequacy of existing stormwater facilities and evaluate future needs. This assessment includes:

1. Identification of physical characteristics of the tributary area which impact stormwater runoff amounts and depths to the University/Midvale intersection.

2. Evaluation of the adequacy of the existing box culvert system serving the University/Midvale intersection to convey stormwater discharges,

3. The formulation of alternatives for alleviating existing flooding problems in the study area.

4. Recommendation of the most cost-effective alternative for alleviating existing flooding problems in the study area.

The results of this study will serve as a guideline for Village of Shorewood Hills and City of Madison officials to evaluate how best to alleviate flooding conditions within the study area.

ES.02 CONTRIBUTING WATERSHED AND EXISTING DRAINAGE SYSTEM

The University Avenue/Midvale Boulevard intersection is served by a mainline box culvert system draining northerly along Midvale Boulevard and Rose Place, passing under the Kohl's grocery store to Locust Avenue, then turning easterly along the Chicago, Milwaukee, St. Paul, and Pacific railroad right-of-way. The culvert follows University Avenue from Grand Avenue to just east of Walnut Street. At this point, the culvert turns northerly, eventually crossing Campus Drive, and discharging into Willow Creek. The culvert varies in size from 12-feet (wide) by 4.5-feet (high) near the outlet to 15-feet (wide) by 6-feet (high) from Shorewood Boulevard to University Bay Drive.

The contributing watershed area to this system includes approximately 1,952 acres to the outlet at Willow Creek. Approximately 1,180 acres of this area are directly tributary to the University Avenue/Midvale Boulevard intersection. Approximately 84 percent of the total

1952 acres within the watershed lies within the City of Madison, with the remaining portion in the Village of Shorewood Hills.

ES.03 METHOD AND RESULTS OF ANALYSIS

The computer program HEC-1, developed by the U.S. Army Corps of Engineers, was used to generate stormwater runoff hydrographs for existing conditions from the tributary area. To determine the capacity of the existing mainline culvert and analyze the performance of proposed alternatives, the Extended Transport (EXTRAN) module of the Stormwater Management Model (SWMM) computer program, developed by the United States Environmental Protection Agency, was used. EXTRAN is a dynamic flow routing model that routes inflow hydrographs through an open channel and/or closed conduit system, computing the time history of flows and hydraulic heads throughout the system.

Computer modeling results indicate that the existing culvert has a hydraulic capacity of only approximately thirty percent of the anticipated inflow to the culvert for a one hundred-year storm and a hydraulic capacity of less than the anticipated peak discharge for a ten-year year storm. Stormwater flows in excess of the existing culvert capacity overflow to the surface through manholes and inlets, inundating the Garden Homes subdivision, Kohl's parking lot area, and the University/Midvale intersection. In the event of a 100-year storm, computer models indicate that as much as 3,000,000 cubic feet of stormwater volume may overflow the drainage system. During the June 17, 1996 storm event, an estimated 800,000-1,000,000 cubic feet of stormwater overflowed the drainage system.

ES.04 ALTERNATIVES ANALYSIS

To identify the most cost-effective solution to alleviate flooding problems near the University/Midvale intersection, several individual plan components were evaluated. These plan components included the following:

1. Provision of Stormwater Detention at Rennebohm Park.

2. Provision of Stormwater Detention at Lucia Crest Park.

3. Provision of a Stormwater Detention Chamber underneath the Kohl's Parking Lot.

4. Construction of a relief sewer to the existing outlet at Willow Creek.

5. Construction of a new relief tunnel under Blackhawk Country Club discharging to Lake Mendota.

6. Floodproofing the existing Garden Homes Subdivision.

To determine the most cost-effective stormwater management plan, 14 alternatives consisting of various combinations of these individual stormwater management components were developed. The lowest cost alternative evaluated was $1,890,000 for floodproofing individual homes in the Garden Homes Subdivision. However, this alternative would provide the least overall benefit since it would continue to allow flooding of the Kohl's Shopping Center site, the University/Midvale intersection, and other points eastward. The lowest cost alternative which would provide a 100-year level of protection is construction of a 108-inch diameter relief tunnel underneath Blackhawk Country Club to Lake Mendota.

The most expensive alternatives analyzed were those including construction of an underground storage chamber in the Kohl's Parking Lot. This is because the structure would have to be extremely large and as deep as 50 feet to have sufficient capacity to significantly reduce peak discharge rates. Also, construction of a relief culvert eastward to Willow Creek along the existing culvert route was determined to be prohibitively expensive due to the size and length of the culvert required and the potential conflicts encountered.

ES.05 RECOMMENDED ALTERNATIVE

Construction of a 108-inch diameter relief tunnel under Blackhawk Country Club, is the recommended alternative for alleviating flooding at the Midvale Boulevard/University Avenue intersection. The justification for this recommendation is:

1. It appears to be the lowest cost alternative for providing a 100-year level of protection, in accordance with project design criteria.

2. Most of the work could be performed in public right-of-way (either City of Madison or Village of Shorewood Hills) so that acquisition of private or park lands should not be necessary. Easements for work within the Chicago, Milwaukee, St. Paul, and Pacific railroad right-of-way would be required.

3. Due to the depth of the tunnel, there should be a relatively minimal number of utility conflicts, and minimal disruption to traffic.

4. The cost difference for tunneling various pipe sizes is not significant. Therefore, it is prudent to construct the largest practical tunnel to prevent additional work at a later date.

Construction of the Blackhawk Relief Tunnel would include the following:

1. Construction of a diversion structure at the Midvale/University intersection to direct culvert flow in excess of the existing culvert capacity (approximately 350 cfs) to the new tunnel.

2. Construction of an 11-foot (wide) by 6-foot (high) box culvert westerly from the junction chamber to Burbank Place, then northerly along Burbank Place to Locust Drive, then westerly along Locust Drive approximately 400 feet. From this point, a 108-inch diameter tunnel approximately 2,300 feet in length would be constructed in a northwesterly direction under Blackhawk Country Club. The tunnel would outlet to Lake Mendota at the marina.

3. Construction of an outlet structure at the marina to dissipate energy prior to discharge into Lake Mendota. Restoration of the marina and shoreline would be completed.

4. Construction of special inlet structures at low points near, and north of, the University/Midvale intersection to intercept surface flow so that the 100-year storm flow is collected and transported from the surface to the underground drainage system.

5. Restoration of streets and terraces, including the University/Midvale intersection, Burbank Place, and Locust Street, would be completed. Utility relocations along Burbank Place would likely be necessary.

Completion of this work would upgrade the level of protection of the Kohl's site, Garden Homes subdivision, and adjacent areas from less than a 10-year storm frequency (10 percent annual recurrence probability) to a 100-year storm frequency (1 percent recurrence probability).

ES.06 OPINION OF PROBABLE PROJECT COST

The probable cost of the recommended alternative is $6,739,000, including engineering and contingencies. A cost-sharing agreement for this work should be negotiated between the City of Madison and the Village of Shorewood Hills to fund the project.

SECTION 1
INTRODUCTION

1.01 INTRODUCTION

Flooding near the University Avenue/Midvale Boulevard intersection has been a concern of both the City of Madison and Village of Shorewood Hills for over fifty years. Public records indicate severe flooding has occurred on numerous occasions, with damages impacting single family homes and commercial lots. In addition, recurrent flooding has resulted in closure of both University Avenue, a major east-west arterial street, and Midvale Boulevard, a major north-south arterial street.

To address this issue, several studies have been undertaken in the past by the City of Madison and the Village of Shorewood Hills. Records indicate that various studies were completed in 1945, 1954, 1964, and 1966. Flood relief alternatives evaluated include stormwater detention, improvement of the culvert capacity easterly along University Avenue, and construction of a relief tunnel underneath Blackhawk Golf Course to Lake Mendota. Recommendations included construction of a 78-inch relief tunnel. This work, however, was never performed.

Recent residential flooding and consideration of redeveloping commercial properties in the area has spurred renewed interest in resolving the recurrent flooding problem in the area. Strand Associates, Inc. was hired in July 1997, to update the previous studies and recommend a new strategy for alleviating existing flooding problems. Results of this investigation are summarized in this report.

1.02 PURPOSE AND SCOPE OF STUDY

The intent of this report is to analyze drainage conditions within the area tributary to the existing culvert system which serves the University Avenue/Midvale Boulevard intersection to assess the adequacy of existing stormwater facilities and evaluate future needs. This assessment includes:

1. Identification of physical characteristics of the tributary area which impact stormwater runoff amounts and depths to the University/Midvale intersection.

2. Evaluation of the adequacy of the existing box culvert system serving the University/Midvale intersection to convey stormwater discharges,

3. The formulation of alternatives for alleviating existing flooding problems in the study area.

4. Recommendation of the most cost-effective alternative for alleviating existing flooding problems in the study area.

The results of this study will serve as a guideline for Village of Shorewood Hills and City of Madison officials to evaluate how best to alleviate flooding conditions within the study area. The study area is found in Figure 1.02-1.

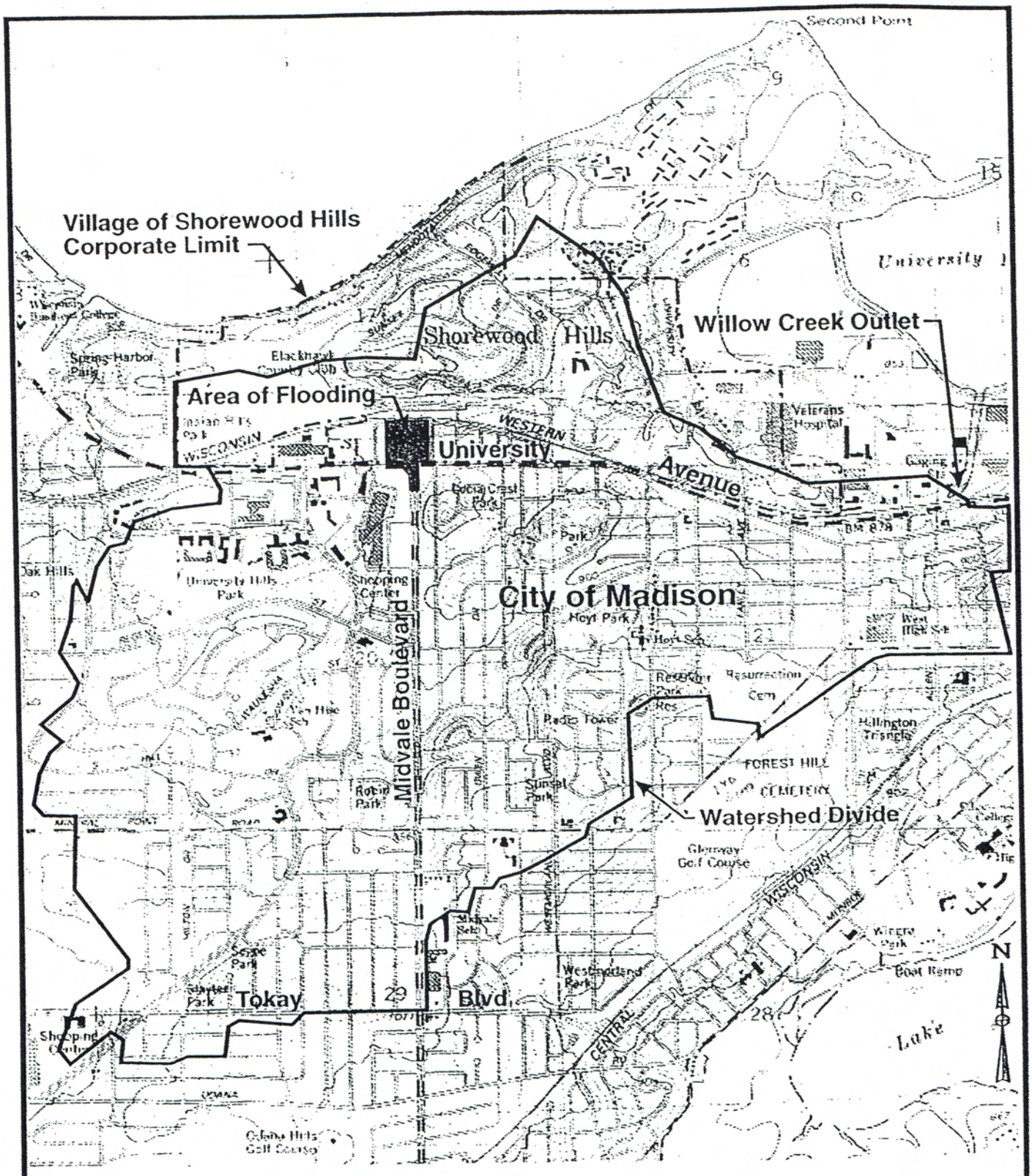
1.03 DESIGN CRITERIA

Traditionally, design of stormwater management facilities is on a "design storm" basis. A design storm is a theoretical storm event recurring at a statistically determined interval. Stormwater discharge from a storm up to and including the severity of the designated design storm will be managed by the proposed drainage facility. Storm events exceeding the design storm may exceed the capacity of the facility and must be managed through other means, such as overland flow.

The statistical basis for the analysis of storm events is the recurrence interval. The recurrence interval is defined as the average interval between the occurrence of a storm of a specified magnitude and an equal or larger storm. If a storm event has a recurrence interval of x years, then the probability of it being equaled or exceeded in any given year is 1/x. Therefore, a "one-hundred year storm" has a one in one-hundred, or one percent, chance of occurring in a given x year. The determination of the recurrence interval is based upon long-term precipitation data for the region. Therefore, on average, a one-hundred year storm will occur once in one hundred years. However, this does not imply that a one-hundred year storm cannot occur more than one time in a one-hundred year period, nor does it imply that a one-hundred year storm will definitely occur in a one-hundred year period.

Typically, municipal drainage networks consist of minor and major drainage systems. The minor system, consisting of facilities such as storm sewers, ditches, and roadway inlets is designed to carry nuisance flooding for convenience, health, and safety. A typical minor system would be for a design storm of a five- to ten-year return frequency. The major system, consisting of major drainageways, detention ponds, and overland flow routes, is typically designed to prevent structural damages and endangerment of human life. A typical major system design storm event is the one-hundred year recurrence interval.

The University/Midvale intersection is served by a series of culverts. Since the intersection is located in a large depression, there is no overland flow route available. Therefore, the drainage system must serve as both the major and minor flow route. For this reason, and because occurrence of a one-hundred year storm event under present conditions could cause significant flood damages, it is recommended that all drainage improvements be designed for a one-hundred year recurrence frequency.



Source: USGS Madison West, WI Topographic Quadrangle
(7.5 Minute Series)
Scale: 1" = 2000'

Figure No. 1.02-1	Village of Shorewood Hills University Avenue / Midvale Boulevard Stormwater Management Study General Location Map	STRAND ASSOCIATES, INC.

SECTION 2
CONTRIBUTING WATERSHED CHARACTERISTICS AND EXISTING DRAINAGE SYSTEM

2.01 OVERVIEW OF TRIBUTARY AREA

This study includes an investigation of the existing trunk line culvert system serving the University Avenue/Midvale Boulevard intersection. The limits of detailed hydraulic analysis of this system are approximately the Vernon Boulevard/Midvale Boulevard intersection to the culvert outlet at Willow Creek, which is east of Walnut Street and north of Campus Drive.

Municipality	Contributing Watershed Area (Ac)	Percentage of Total Watershed Area
Village of Shorewood Hills	321	16.4%
City of Madison	1631	83.6%
TOTAL	1952	100%

Table 2.01-1 Relative Contribution of Watershed Areas

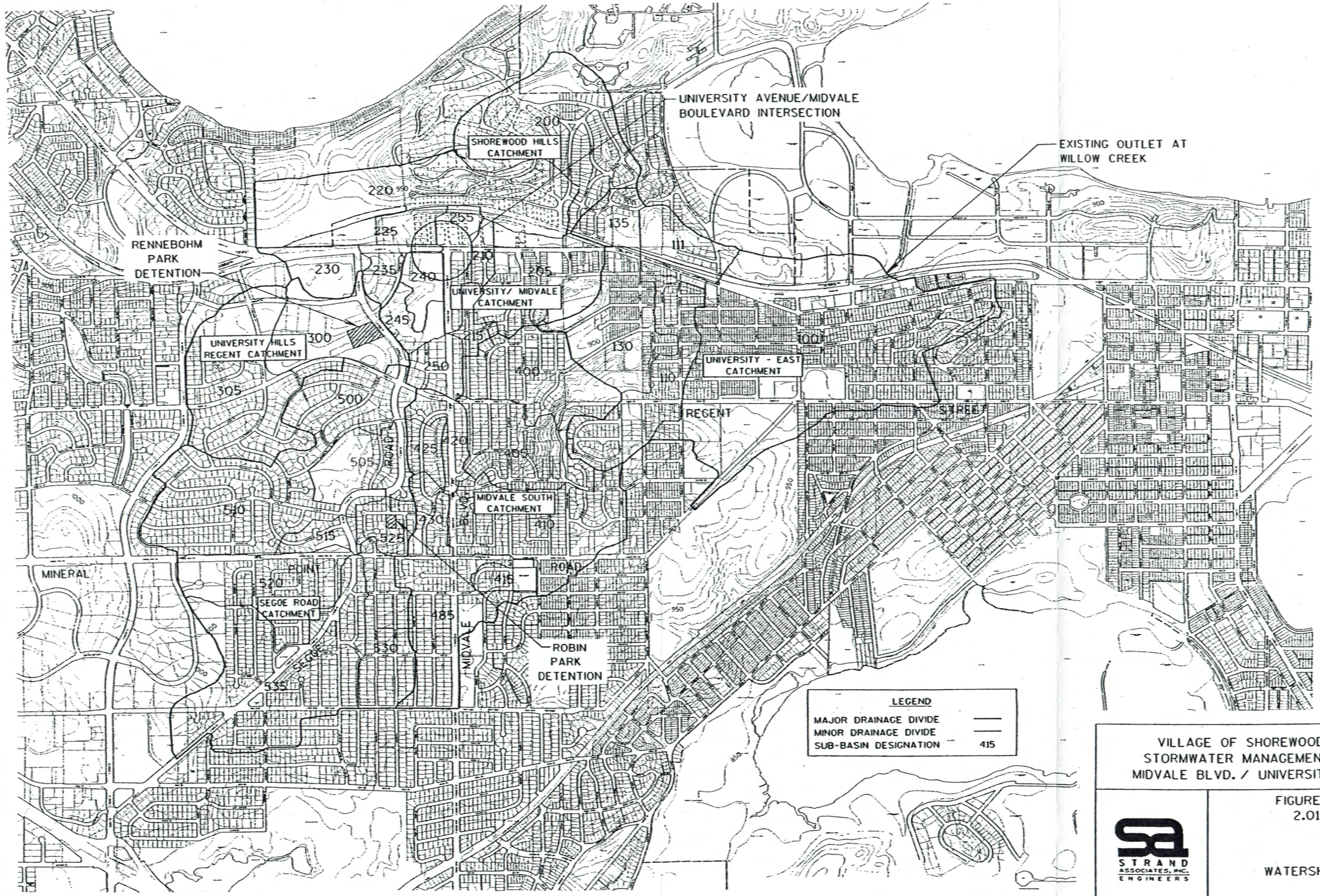
The contributing watershed to this system includes approximately 1,952 acres to the outlet at Willow Creek. Approximately 1,180 acres of this area are directly tributary to the University Avenue/Midvale Boulevard intersection. Table 2.01-1 includes a breakdown of the relative portions of the watershed located in the Village of Shorewood Hills and the City of Madison.

2.02 WATERSHED SUBBASINS

For purposes of this study, the contributing watershed has been divided into several smaller subbasins. Basin divisions were selected with consideration of topography, homogeneity of land usage, and locations of major drainage systems. Descriptions of subbasin areas are included in this section.

A. Segoe Road Catchment

This 505 acre catchment includes tributary areas to the Segoe Road drainage system, and includes Subbasins 500-535, as identified in Figure 2.01-1. Included in this catchment are areas generally along Segoe Road, extending southerly to Tokay Boulevard, and northerly to approximately Regent Street. The area is primarily medium density residential, with moderately sloping terrain. The main drainage system serving this area consists of a box culvert in the median of Segoe Road ranging in size from seven-feet (wide) by 2.5-feet (high), to seven feet (wide) by four feet (high). This culvert discharges to the box culvert at Vernon Boulevard.



VILLAGE OF SHOREWOOD HILLS
STORMWATER MANAGEMENT STUDY
MIDVALE BLVD. / UNIVERSITY AVENUE

STRAND ASSOCIATES, INC. ENGINEERS

FIGURE NO.
2.01-1

WATERSHED MAP

B. Midvale South Catchment

This 349 acre catchment includes tributary areas to the Midvale Road drainage system, and includes Subbasins 400-435, as identified in Figure 2.01-1. Included are areas generally along, and mostly east of, Midvale Boulevard extending southerly to Tokay Boulevard, and northerly to approximately Regent Street. The area is primarily medium density residential, with moderately to steeply sloping terrain. Several drainage systems serve this area, including seven-foot (wide) by 2.5 foot (high) open concrete flumes draining northerly in the mid-block areas between Midvale Boulevard and Hillcrest Drive, and between Midvale Boulevard and Merlham Drive; an open ditch serving the Sunset Village subdivision east of Midvale Boulevard and south of Hillcrest Drive; and a 30-inch storm sewer serving the Midvale Terrace Subdivision east of Midvale Boulevard and north of Regent Street. These systems join at Midvale Boulevard and are carried to a junction with systems serving the Segoe Road and University Hills/Regent Street catchments at Vernon Boulevard.

C. University Hills/Regent St. Catchment

This 164 acre catchment includes Subbasins 300-310, as identified in Figure 2.01-1. Included are areas generally along Regent Street, west of Segoe Road. The catchment includes commercial office development and multi-family housing, as well as low to medium density residential development. Rennebohm Park occupies approximately a twenty acre portion of the catchment. The main drainage system consists of a 30- to 36-inch storm sewer crossing Rennebohm Park. This storm sewer discharges to an open channel with a concrete invert, draining easterly to a detention basin near Segoe Road. The detention basin discharges via a control structure to a seven-foot (wide) by three-foot (high) box culvert at Segoe Road. The control structure consists of a three foot high weir with three twelve inch rectangular orifices.

D. University/Midvale Catchment

This 231 acre catchment includes areas draining directly to University Avenue west of Shorewood Boulevard and directly to Midvale Boulevard north of Regent Street, including Subbasins 205-215 and 225-255, as identified in Figure 2.01-1. A large amount of highly intensive land usage, including the Hilldale Shopping Center, Kohl's Shopping Center, and other commercial and office developments are present in this catchment. Ground slopes are generally flat, with standing water common after large rain events. The main drainage system consists of a twelve-foot (wide) by five foot (high) box culvert running in a northerly direction along Midvale Boulevard to Locust Avenue. At Locust Avenue, the culvert turns easterly and runs parallel to the Chicago, Milwaukee, St. Paul, and Pacific railroad right-of-way to Shorewood Boulevard.

E. Shorewood Hills Catchment

This 296 acre catchment includes areas draining from the Village of Shorewood Hills, north of the Chicago, Milwaukee, St. Paul, and Pacific Railroad right-of-way, including Subbasins 111, 135, 200, and 220, as shown in Figure 2.01-1. The area is primarily medium density residential, with steeply sloping terrain. The catchment drains southerly to an existing open ditch located north of the Chicago, Milwaukee, St. Paul, and Pacific Railroad tracks. The open ditch carries stormwater discharge easterly to Shorewood Boulevard, where it discharges to the main box culvert system, via an 18-inch restricted opening with a check valve. Additional flow is carried into the main system from a 48-inch storm sewer along Shorewood Boulevard.

F. University East Catchment

This 407 acre catchment includes areas east of Shorewood Boulevard directly tributary to the main culvert system, including Subbasins 100, 110, and 130, as shown in Figure 2.01-1. Stormwater runoff from this area does not directly impact the University/Midvale Intersection. However, it is included in the analysis because it impacts the downstream capacity of the culvert system serving the intersection. The area includes a large amount of commercial and high density residential development, and has moderate to flat ground slopes.

2.03. LAND USE

As indicated in Table 2.03-1 and Figure 2.03-1, overall land use in the watershed is predominately low to high density residential (65%), with a substantial portion of commercial development also present (23%). The watershed is almost fully developed, with open space areas occupying only approximately twelve percent of the total area. Most of this open space is either park lands or school grounds.

Since the area is nearly fully developed, it is not anticipated that future conditions stormwater discharges will substantially increase in comparison with existing conditions discharges.

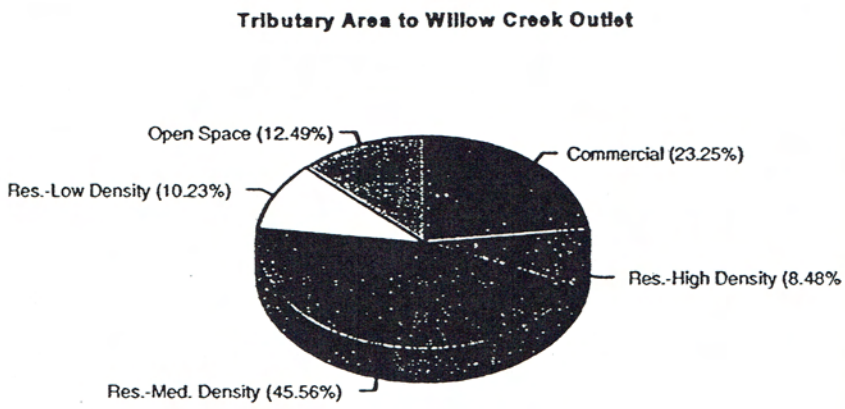


Figure 2.03-1 Watershed Land Use Breakdown

The limits of the watershed are identified in Figure 2.03-1.

Subbasin Designation	Land Use (Ac) Commercial	High Density Residential	Medium Density Residential	Low Density Residential	Open Space	Total Area (Ac)
University - East						
100	79.5	84.2	63.1		41.2	268.0
110	11.2	25.3	27.8	3.3	7.3	74.9
130	23.0	28.4	7.6	—	5.4	64.4
Subtotal	113.7	137.9	98.5	3.3	53.9	407.3
University/Midvale						
205	29.2	10.0	15.1		14.6	68.9
210	5.4		4.4			9.8
215			9.5			9.5
225	14.9	6.3			6.6	27.8
230	23.3					23.3
235	16.8					16.8
240	16.0					16.0
245	16.6					16.6
250	14.8		4.2			19.0
255	12.8	2.2	7.6	—	0.7	23.3
Subtotal	149.8	18.5	40.8	0.0	21.9	231.0
University Hills/Regent						
300	43.3				18.9	62.2
305	21.1		28.0	44.8	2.4	96.3
310	—	—	—	5.3	—	5.3
Subtotal	64.4	0.0	28.0	50.1	21.3	163.8
Shorewood Hills						
111	22.0	0.0	5.0	0.0	0.0	27.0
135	10.0	0.0	5.0	0.0	15.0	30.0
200	23.2	0.0	25.4	47.7	15.0	111.3
220	3.5	0.0	43.3	12.7	67.8	127.3
Subtotal	58.7	0.0	78.7	60.4	97.8	295.6
Midvale South						
400	7.1		36.0	7.3	13.9	64.3
405			48.1	0.9	6.9	55.9
410	5.4	9.1	82.3			96.8
415	3.4		6.2			9.6
420	2.4		17.3			19.7
425			14.0			14.0
430	2.0		17.6			19.6
435	3.7	—	61.7	—	3.7	69.1
Subtotal	24.0	9.1	283.2	8.2	24.5	349.0
Segoe Road						
500	5.1		7.3	41.6		54.0
505	5.8		18.0		15.7	39.5
510	1.0		99.9	11.9		112.8
515	2.5		12.4			14.9
520	11.2		52.0	4.7	3.1	71.0
525			17.3		2.0	19.3
530			49.4			49.4
535	17.5		103.7	19.5	3.5	144.2
Subtotal	43.1	0.0	360.0	77.7	24.3	505.1

Table 2.03-1 Land Use Summary

2.04 SOILS

The amount of stormwater runoff produced by a storm event is greatly impacted by the types of soil underlying the watershed. Soils consisting of a high percentage of sand and gravel will tend to absorb a higher percentage of stormwater than will soils having a high clay content. Therefore, relatively less stormwater runoff will occur in sandy areas.

According to the Dane County, Wisconsin Soils Survey, published by the U.S. Department of Agriculture in cooperation with the Research Division of the College of Agricultural and Life Sciences, University of Wisconsin, local soils are primarily silt loams. These soils are classified by the Soil Conservation Service in Hydrologic Soil Group B, meaning they are moderately well to well-drained soils with moderately fine to moderately coarse textures. Stormwater will typically infiltrate into these soils at a rate of 0.15 to 0.30 inches per hour.

2.05 PRECIPITATION DEPTHS

Potential sources of stormwater runoff include rainfall, snow melt, groundwater, or a combination of these. A review of precipitation records for the project area indicates that the highest potential for flooding results from intense rainstorm events. Therefore, for this study, stormwater runoff modeling was based strictly upon rainfall events.

Rainfall depths for the City of Madison were obtained from the publication *Rainfall Frequency of the Midwest* (Bulletin 71), by the Midwestern Climate Center. This document is an atlas of rainfall depths for various storm durations based upon several decades of data from a network of rainfall gauges. Rainfall depths for storm events of various durations and return frequencies are summarized in Table 2.05-1.

	Precipitation Depth (in)				
Frequency	30-min	1-Hour	3-Hour	6-Hour	24-hr
2-Year	1.03	1.31	1.78	2.09	2.78
5-Year	1.31	1.66	2.26	2.65	3.53
10-Year	1.55	1.97	2.69	3.15	4.20
50-Year	2.24	2.85	3.88	4.55	6.06
100-Year	2.61	3.32	4.52	5.30	7.06

Reference: Huff, Floyd A., and Angel, James R., Rainfall Frequency Atlas of the Midwest, Midwestern Climate Center, Bulletin 71, Table 9, 1992.

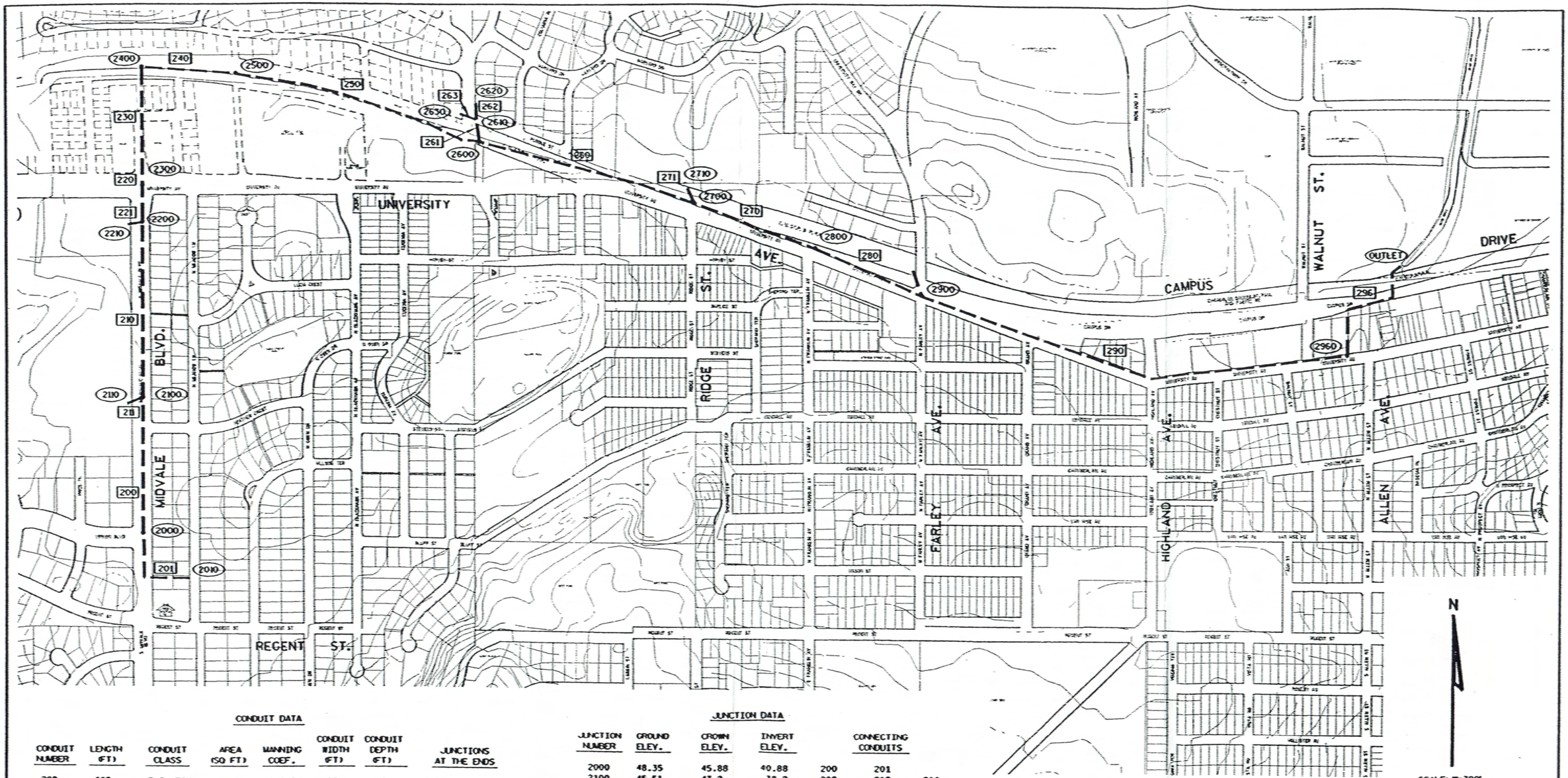
Table 2.05-1 Precipitation Data

Precipitation depths were distributed over various storm durations modeled using the First Quartile Huff Rainfall Distribution.

2.06 EXISTING DRAINAGE SYSTEM

The University Avenue/Midvale Boulevard intersection is served by a mainline box culvert system draining northerly along Midvale Boulevard and Rose Place, passing under the Kohl's grocery store to Locust Avenue, then turning easterly along the Chicago, Milwaukee, St. Paul, and Pacific railroad right-of-way. The culvert follows University Avenue from Grand Avenue to just east of Walnut Street. At this point, the culvert turns northerly, eventually crossing Campus Drive, and discharging into Willow Creek. The culvert varies in size from twelve feet (wide) by 4.5 feet (high) near the outlet to 15 feet (wide) by 6 feet (high) from Shorewood Boulevard to University Bay Drive. The layout of the culvert, along with relevant physical data is included in Figure 2.06-1.

A visual inspection of the culvert was performed by City of Madison engineers in September, 1997. City staff reports that, in general, the culvert is in fairly good structural condition.



CONDUIT DATA

CONDUIT NUMBER	LENGTH (FT)	CONDUIT CLASS	AREA (SQ FT)	MANNING COEF.	CONDUIT WIDTH (FT)	CONDUIT DEPTH (FT)	JUNCTIONS AT THE ENDS	
200	680	R.C. BOX	60	0.016	12	5	2000	2100
210	1190	R.C. BOX	60	0.016	12	5	2100	2200
220	240	R.C. BOX	60	0.016	12	5	2200	2300
230	640	R.C. BOX	60	0.016	12	5	2300	2400
240	630	R.C. BOX	60	0.016	12	5	2400	2500
250	1440	R.C. BOX	60	0.016	12	5	2500	2600
260	1420	R.C. BOX	75	0.016	15	5	2600	2700
270	770	R.C. BOX	90	0.016	15	6	2700	2800
280	700	R.C. BOX	90	0.016	15	6	2800	2900
290	2530	R.C. BOX	72	0.016	12	6	2900	2960
296	750	R.C. BOX	54	0.016	12	4.5	2960	OUTLET
221	100	R.C. PIPE	4.91	0.016	2.5	2.5	2210	2200
211	100	R.C. PIPE	4.91	0.016	2.5	2.5	2110	2100
201	330	R.C. PIPE	4.91	0.016	2.5	2.5	2010	2000
261	80	R.C. BOX	25	0.016	5	5	2610	2600
262	100	R.C. PIPE	9.62	0.016	3.5	3.5	2620	2610
263	100	R.C. PIPE	9.62	0.016	3.5	3.5	2630	2610
271	100	R.C. PIPE	9.62	0.016	3.5	3.5	2710	2700
291	150	R.C. PIPE	0.79	0.016	1	1	2910	2900

JUNCTION DATA

JUNCTION NUMBER	GROUND ELEV.	CROWN ELEV.	INVERT ELEV.	CONNECTING CONDUITS			
2000	48.35	45.88	40.88	200	201		
2100	45.51	43.2	38.2	200	210	211	
2200	40.25	38.13	33.13	210	220	221	
2300	39.66	36.63	31.63	220	230		
2400	38.67	32.74	27.74	230	240		
2500	42.45	32.73	27.73	240	250		
2600	36.68	30.55	25.55	250	260	261	
2700	34.49	29.83	23.83	260	270	271	
2800	30.85	28.6	22.6	270	280		
2900	31.03	27.73	21.73	280	290	291	
2960	27.18	19.05	13.05	290	296		
OUTLET	12.28	5.7	1.2	296			
2210	45	37.5	35	221			
2110	48.5	41.5	39	211			
2010	50	44.78	42.28	201			
2610	36	35	30	261	262	263	
2620	35	34.5	31	262			
2630	36	34.5	31	263			
2710	33.5	32	28.5	271			
2910	31.5	29	28	291			

LEGEND

EXISTING BOX CULVERT

SWMM CONDUIT NUMBER [201]

SWMM JUNCTION NUMBER (2000)

VILLAGE OF SHOREWOOD HILLS
STORMWATER MANAGEMENT STUDY
MIDVALE BLVD. / UNIVERSITY AVENUE

STRAND ASSOCIATES, INC. ENGINEERS

FIGURE NO.
2.06-1

EXISTING DRAINAGE SYSTEM

SECTION 3
STUDY METHODOLOGY AND RESULTS

3.01 STUDY METHODOLGY

A. Method of Estimating Storm Flows

The volume of stormwater produced by a rainfall event is dependent, primarily, upon the following factors:

1. The depth, duration, and spatial and temporal distribution of precipitation.

2. The size of the drainage area upstream from the point of concern.

3. The land cover (e.g., grass, pavement, etc.) of the tributary drainage area.

4. The travel time from the most remote portions of the watershed to the point of concern.

5. The type and degree of saturation of the underlying soils.

6. The presence and extent of stormwater storage areas in the floodplain and watershed.

7. The presence of manmade structures within the watershed which accelerate or restrict flows to downstream areas.

To model runoff characteristics of a watershed, hydrologists typically produce and analyze graphs of flow versus time, known as hydrographs, at the point of interest in the watershed. Hydrographs can be mathematically manipulated to determine the effects of adding or removing storage volume, accelerating or slowing travel times, or adding or reducing the amount of imperviousness. Analysis of hydrographs in this manner enables evaluation of existing and future conditions and impacts of proposed alternatives on stormwater flows.

For this project, the computer program HEC-1, produced by the U.S. Army Corps of Engineers, was used to generate hydrographs for existing conditions. Input to HEC-1 included mathematical parameters representing precipitation depth and distribution, drainage areas, land usage, and flow times for each of the 36 subbasins identified in Figure 2.01-1. The result is a rainfall-runoff model for the storm frequency of interest in the watershed. For this study, hydrographs of the 10-year, 50-year and 100-year storm events were produced. A range of storm durations were modeled to determine the storm duration producing the highest peak discharge for each storm frequency.

A summary of HEC-1 input parameters is included in Table 3.01-1.

Subbasin Designation	Subbasin Area (acres)	Subbasin Area (sq. mi.)	Runoff Curve Number	Time of Concentration (hr)	Lag Time (hr)
Shorewood Hills					
111	27.0	0.042	92	0.33	0.20
135	30.0	0.0469	77	0.62	0.37
200	161.2	0.2517	75	0.8	0.48
220	89.3	0.1395	69	1.12	0.67
University - East					
100	268.0	0.4327	78	0.62	0.37
110	73.9	0.1254	85	0.48	0.29
130	65.4	0.1302	86	0.41	0.25
University/Midvale					
205	68.8	0.1075	86	0.4	0.24
210	9.8	0.0153	86	0.36	0.22
215	9.5	0.0148	77	0.30	0.18
225	27.8	0.0435	83	0.26	0.16
230	23.3	0.0364	92	0.13	0.08
235	16.8	0.0263	92	0.17	0.10
240	16.0	0.0250	92	0.09	0.05
245	16.6	0.0259	94	0.08	0.05
250	19.0	0.0296	89	0.12	0.07
255	23.3	0.0363	87	0.70	0.42
University Hills/Regent					
300	62.2	0.0971	83	0.95	0.57
305	96.2	0.1503	77	0.51	0.31
310	5.3	0.0083	71	0.51	0.31
Midvale South					
400	64.3	0.1005	79	0.6	0.36
405	55.9	0.0874	76	0.44	0.26
410	96.7	0.1510	77	0.72	0.43
415	9.5	0.0149	81	0.13	0.08
420	19.7	0.0307	77	0.63	0.38
425	14.0	0.0218	75	0.48	0.29
430	19.5	0.0305	77	0.43	0.26
435	69.1	0.1080	76	0.72	0.43
Segoe					
500	53.9	0.0842	74	0.71	0.43
505	39.5	0.0617	72	0.82	0.49
510	112.4	0.1755	75	0.54	0.32
515	14.9	0.0232	78	0.32	0.19
520	70.9	0.1108	77	0.44	0.26
525	19.2	0.0300	74	0.41	0.25
530	49.0	0.0772	75	0.79	0.47
535	144.2	0.2252	77	1.25	0.75

Table 3.01-1 Summary of Hydrologic Parameters

B. Method of Determining Culvert Capacity

To determine the capacity of the existing mainline culvert and analyze the performance of proposed alternatives, the Extended Transport (EXTRAN) module of the Stormwater Management Model (SWMM) computer program, developed by the United States Environmental Protection Agency was used. EXTRAN is a dynamic flow routing model that routes inflow hydrographs through an open channel and/or closed conduit system, computing the time history of flows and heads throughout the system. Input to EXTRAN includes the following:

1. The physical geometry of the culvert system. This includes culvert sizes and shapes, ground and invert elevations, and culvert connectivity information. For this project, physical information regarding the culvert system was obtained from the City of Madison storm sewer atlas along with actual field survey information.

2. Data regarding special hydraulic structures in the system such as weirs, check valves, and storage junctions.

3. Roughness coefficients for existing and proposed conduits.

4. Inflow hydrographs at critical nodes in the system. For this project, hydrographs were computed using the HEC-1 computer program, as described in Section 3.01A and read into the EXTRAN model.

5. Boundary conditions defining starting water surface elevations and other inlet and outlet conditions. For this project, the approximate ten-year lake level, obtained from FEMA mapping was used as the downstream starting water surface elevation.

Output information from the EXTRAN model includes the following:

1. Time histories of flows and depths through individual culvert reaches for various storm events.

2. Estimates of cumulative stormwater volumes overflowing the system at various locations for extreme storm events.

3.02 RESULTS OF HYDROLOGIC AND HYDRAULIC MODELING

A. Evaluation June 16-17, 1996 Storm Event

Major flooding of the study area last occurred on June 16 and 17, 1996. This consisted of two individual storm events. The first occurred between the hours of approximately 11 P.M. and 6 A.M. on June 16, during which time approximately 3.6 inches of precipitation fell. The second event occurred between the hours of approximately 6 P.M. and 8 P.M. on June 17, during which time approximately 2.9 inches of precipitation fell. Although the June 17 event was less severe than the morning event, a greater amount of flooding apparently occurred. This is likely due to the fact that the ground was saturated in the evening because of the morning event. Therefore, a greater portion of the evening rainfall became surface runoff, rather than infiltration, compared to the morning event. The rainfall pattern of the June 16-17 storm is shown in Figure 3.02-1.

Reports from Village of Shorewood staff and residents indicate that the University Avenue/Midvale Boulevard intersection was flooded with depths of up to three feet. The Kohl's parking lot experienced flooding depths in some locations of as much as four feet. Widespread basement and surface flooding occurred in the Garden Homes subdivision, just northwest of the intersection.

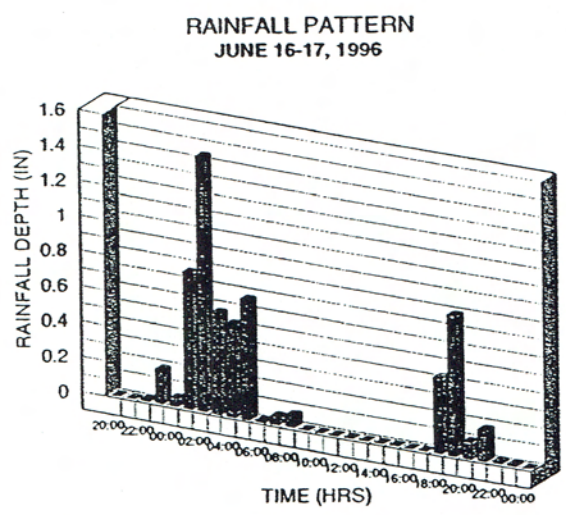


Figure 3.02-1 Rainfall Pattern

To determine the effectiveness of the hydrologic and hydraulic models for predicting peak discharges and volumes, the rain event of June 17, 1996, was modeled. Precipitation measured by recording rainfall gages at the Madison Airport and various sites at the University of Wisconsin was obtained and input to the HEC-1 model to generate inflow hydrographs. HEC-1 hydrographs were input to the EXTRAN model to simulate the performance of the existing culvert system. According to the EXTRAN model, approximately 17 acre-feet of stormwater discharged from the drainage system onto the surface between Junctions 2000 and 2400, which would cause inundation of the University/Midvale intersection, Kohl's parking lot, and Garden Homes subdivision. An approximation of the volume of stormwater actually stored in the study area based on observations of nearby residents indicates that approximately 20 acre-feet was stored.

The runoff hydrograph at the University/Midvale intersection estimated by the HEC-1 model is shown in Figure 3.02-2.

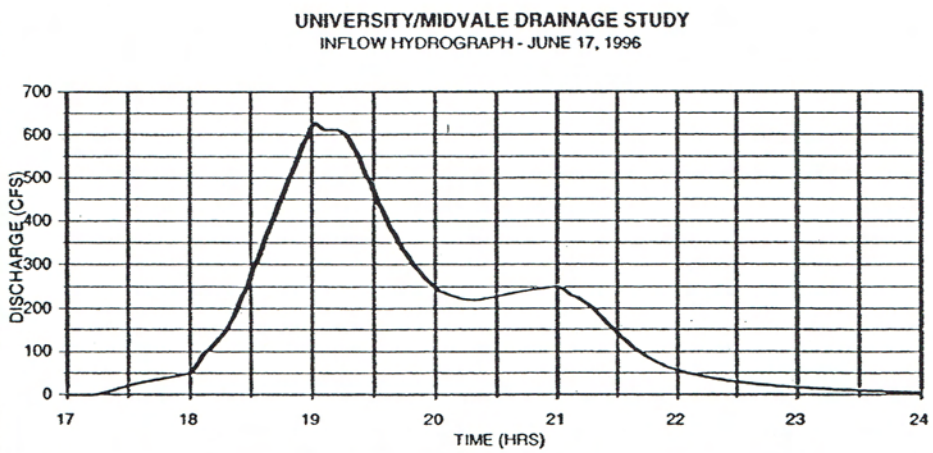


Figure 3.02-2 Inflow Hydrograph - June 17, 1996

Based upon these results, it appears that the model adequately simulates stormwater runoff from the watershed under average antecedent moisture conditions.

B. Stormwater Peak Discharges

Stormwater peak discharges to individual junctions in the existing culvert system were calculated using the HEC-1 computer program. A sensitivity analysis was performed in which 30-minute, 1-, 3-, 6-, 12-, and 24-hour storm durations were run to determine which storm duration produced the highest peak discharge at the University/Midvale intersection. Results of this analysis concluded that the 1-hour storm duration produces the highest peak discharges.

Location	Contributing Subbasins	Drainage Area (Ac)	Peak Q (CFS) 10-Year	50-Year	100-Year
Segoe Road Catchment	500-535	505	163	369	502
University Hills / Regent Catchment	300-310	164	45	158	221
Midvale South Catchment	400-485	346	163	368	498
University / Midvale Intersection	215, 230, 235, 240, 245, 250, 255, 300-500	1180	418	934	1,333

Table 3.02-1 Calculated Peak Discharges

A one-hour storm duration was modeled for return frequencies of 10-, 50-, and 100-years (i.e., the 10%, 2%, and 1% probability storms). Resulting peak discharges at various watershed locations are summarized in Table 3.02-1. Inflow hydrographs to the University/Midvale intersection for the 10-, 50-, and 100-year storm events are shown in Figure 3.02-3.

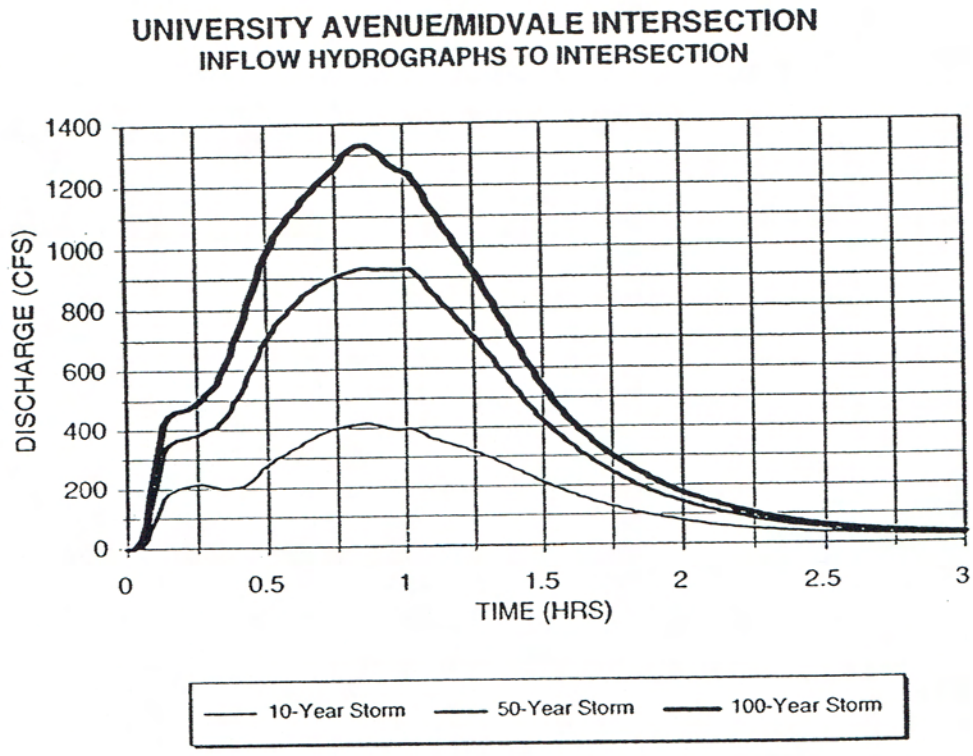


Figure 3.02-3 Inflow Hydrographs to Intersection

C. Existing Culvert Capacity

The EXTRAN model was used to evaluate culvert performance for existing conditions for the 10-year (10%), 50-year (2%), and 100-year (1%) storm events. Computer modeling results indicate that the existing culvert conduits downstream from the University/Midvale intersection have a hydraulic capacity of approximately 400 cfs, in comparison with a 100-year stormwater inflow peak of 1300 cfs. This indicates that the existing culvert capacity is only approximately thirty percent of the anticipated inflow to the culvert for a one hundred-year storm and less than the anticipated peak discharge for a ten-year year storm. Stormwater flows in excess of the existing culvert capacity overflow to the surface through manholes and inlets, inundating the Garden Homes subdivision, Kohl's parking lot area, and the University/Midvale intersection. In the event of a 100-year storm, computer models indicate that as much as 72

acre-feet of stormwater volume may overflow the drainage system. During the June 17, 1996 storm event, an estimated 20 acre-feet of stormwater overflowed the drainage system.

Capacities of individual culvert reaches, overflow volumes, and other relevant hydraulic data for the 10-, 50-, and 100-year storm event are summarized in Table 3.02-2.

			Conduit Discharge (cfs)				Surcharge at Upstream Junction (Acre-Feet)			
EXTRAN Conduit Number	Conduit Size/Type (RC Box)	Conduit Capacity (cfs)	10-Year	50-Year	100-Year	June, 1997	10-Year	50-Year	100-Year	June, 1996
200	12'x5'	511	347	535	535	530	0	12.7	32.6	0.1
210	12'x5'	531	372	541	541	541	0	1.4	2.5	0.0
220	12'x5'	643	382	403	403	403	0	12.2	14.9	7.0
230	12'x5'	634	350	384	433	358	2.6	12.0	15.0	8.2
240	12'x5'	32.4	361	498	576	395	0	3.9	6.7	1.4
250	12'x5'	317	364	486	553	376	0	0	0	0
260	15'x5'	369	466	606	636	472	0	0	0	0
270	15'x6'	555	536	637	719	565	0	0	0	0
280	15'x6'	490	501	637	719	441	10.6	35.8	49.2	20.7
290	12'x6'	622	501	510	513	506	0	0.2	0.1	.01
296	12'x4.5'	875	501	510	513	0	0	0	0	0

Table 3.02-2 Existing Culvert Performance

D. Analysis of Alternatives

To determine the effectiveness of various alternatives for relieving flooding in the study area, the existing conditions EXTRAN model was modified, as required. Modifications included addition of relief culverts of various sizes, installation of control structures, and modifications to inflow hydrographs for upstream stormwater detention alternatives. Results of these analyses form the basis for the discussion in Section 4.

SECTION 4
RECOMMENDED STORMWATER PLAN

4.01 GENERAL

Previous sections of this report have discussed the project background and purpose, existing drainage systems and patterns in the project area, design criteria and goals, and study methodology and results. In this section, a plan for achieving design criteria discussed in Section 1 is presented. Stormwater management facilities have been sized and analyzed in accordance with methodologies presented in Section 3.

4.02 APPROACHES TO STORMWATER MANAGEMENT

Four different approaches are typically considered in identifying solutions to stormwater management issues. *Conveyance* involves constructing relief conduits or channels to increase the drainage system capacity so that in flowing stormwater can be safely conveyed from the site of interest. *Storage* involves constructing impoundments such as detention ponds or underground storage chambers to hold excess stormwater runoff volumes until existing downstream drainage systems can safely drain the impoundment. *Diversion* involves relieving an existing drainage system by redirecting a portion of the contributing flow to another stormwater outlet. *Floodproofing* involves allowing occasional flooding, however, protecting existing structures from damage by elevating, berming, diking, or other measures.

The selection of the most desirable approach is contingent upon a number of project-specific criteria. In developing areas, storage is typically the most desirable solution because availability of open space may not be an issue. Provision of sufficient storage can prevent stormwater peak discharges from increasing downstream in excess of existing drainage system capacities, thus eliminating the need to reconstruct long reaches of existing underground structures. Storage can also be beneficial in providing sedimentation areas for removing stormwater pollutants prior to discharging to lakes or streams.

Where storage is not possible, conveyance solutions may be appropriate. Though commonly more expensive, conveyance facilities tend to be less maintenance-intensive than storage facilities and may reduce the presence of standing water for long periods of time. A major disadvantage is that conveyance solutions can solve flooding issues in one area only to inadvertently create new problems at the next downstream "bottleneck."

Diversion of stormwater is a less common approach. This is because it is often expensive and technically difficult to remove stormwater from its "natural" outlet. Also, as with conveyance alternatives, diversion of stormwater may solve a flooding problem in one area only to create a new problem at some point downstream. However, it may be a viable solution where there is a nearby drainage outlet with excess capacity.

Floodproofing may be a cost-effective solution in cases where conveyance, storage, and diversion solutions are not feasible. The goal of floodproofing is to eliminate structural

damages and significant financial impacts. Floodproofing will not eliminate occasional periods of standing water.

4.03 POTENTIAL COMPONENTS OF STORMWATER MANAGEMENT PLAN

A. General

To identify the most cost effective solution to flooding problems near the University/Midvale intersection, several individual plan components were evaluated. Individual plan components may not singularly alleviate flooding problems. However, a combination of these individual components may prove more cost effective than a single large scale public works project. For this analysis, individual plan components were analyzed separately. Then, 14 stormwater management alternatives were developed based upon various combinations of individual plan components.

Individual plan components included various storage, conveyance, diversion, and floodproofing elements. Each of the individual components analyzed are described in this section and shown graphically in Figure 4.03-1. Stormwater management alternatives based upon various combinations of these components are described in Section 4.04.

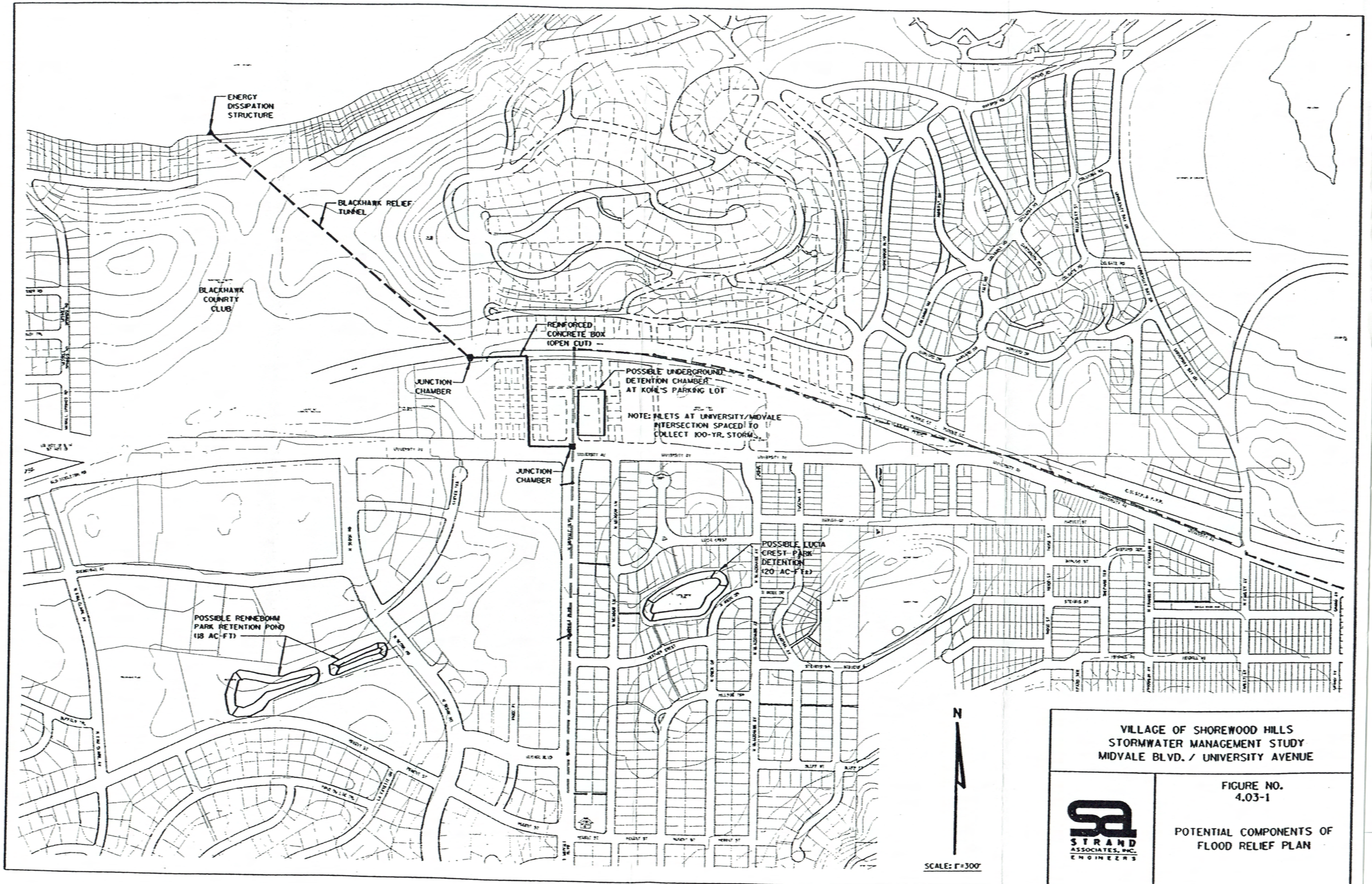
B. Stormwater Detention/Retention Components

Storage alternatives consider the feasibility of providing sufficient stormwater detention to reduce the peak stormwater discharge to a level that can be accommodated by the existing drainage system. Field inspection and review of existing aerial photography indicate that there are three locations in the watershed where the presence of open space may enable construction of stormwater management facilities.

1. Rennebohm Park Detention/Retention Basin

The first location is in Rennebohm Park, west of Segoe Road and south of Regent Street. The western portion of the park is developed, with a pavilion and recreational facilities. A dry detention basin is present at the eastern edge of the park, near Segoe Road. Discharge from the basin is restricted by a three foot high by seven foot long weir, including three one-foot by one foot low flow orifices. Overflow from the structure discharges to a seven foot wide by three foot high box culvert. A tributary area of approximately 164 acres drains to this structure, which comprises approximately 14 percent of the total area to the Midvale/University Avenue intersection.

There is a large amount of open space between the existing detention pond and the developed portion of the park. A detention or wet retention basin providing 15 to 20 acre-feet of storage could be constructed in this area. Hydrologic modeling indicates this could reduce the peak stormwater discharge from the contributing area by as much


ENERGY DISSIPATION STRUCTURE
BLACKHAWK RELIEF TUNNEL
BLACKHAWK COUNTRY CLUB
REINFORCED CONCRETE BOX (OPEN CUT)
JUNCTION CHAMBER
POSSIBLE UNDERGROUND DETENTION CHAMBER AT KOHL'S PARKING LOT
NOTE: INLETS AT UNIVERSITY/MIDVALE INTERSECTION SPACED TO COLLECT 100-YR. STORM.
JUNCTION CHAMBER
POSSIBLE LUCIA CREST PARK DETENTION (20 AC-FT±)
POSSIBLE RENNEBOHM PARK RETENTION POND (18 AC-FT)
N
SCALE: 1"=300'
VILLAGE OF SHOREWOOD HILLS
STORMWATER MANAGEMENT STUDY
MIDVALE BLVD. / UNIVERSITY AVENUE
STRAND ASSOCIATES, INC. ENGINEERS
FIGURE NO. 4.03-1
POTENTIAL COMPONENTS OF FLOOD RELIEF PLAN

as 65 percent, and the overall peak discharge to the Midvale/University Avenue intersection by as much as 15 percent. Increasing the size of the proposed basin beyond 15 to 20 acre feet would probably have little additional benefit at the Midvale/University intersection since the controlled portion of the watershed would be only approximately 14 percent of the overall contributing area.

Results of this analysis indicate that it is not possible to resolve flooding problems at the Midvale/University intersection strictly by the provision of stormwater detention at Rennebohm Park. However, construction of a basin at this location may provide local benefits (such as control of pollutant discharges from the contributing area) and may be beneficial if incorporated into an overall basin-wide plan for reducing stormwater discharges.

2. Lucia Crest Park Detention Basin

The second location where it may be feasible to provide stormwater detention is in Lucia Crest Park, approximately one block east of Midvale Boulevard and one block south of University Avenue. Presently, Lucia Crest Park is located in a natural depression, encompassing an area of approximately five acres. The ground elevation of the park is generally lower than the invert elevation of the existing storm sewer in Midvale Boulevard. Therefore, it would be possible to develop the park site as an off-line, dry detention pond having a storage capacity of approximately twenty acre-feet. This would require providing a control structure and sufficient inlet capacity at Midvale Boulevard to intercept stormwater flow exceeding the capacity of the existing Midvale Boulevard drainage system. Excess stormwater flow would be conveyed by gravity to the park by means of an eleven foot by six foot box culvert. Excess flow would be detained in the basin until after the hydraulic gradient in the Midvale Boulevard system drops below the water surface elevation in the basin. The basin would then drain into the Midvale Boulevard system, possibly with the assistance of pumps.

Hydraulic analysis of this alternative indicates that, like the Rennebohm Park basin option, it is not possible to resolve flooding problems at the Midvale/University intersection strictly by the provision of stormwater detention at Lucia Crest Park. However, construction of a basin at this location may be beneficial if incorporated into an overall basin-wide plan for reducing stormwater discharges. If this plan is incorporated, it would be critical to incorporate dry weather improvements to the park to make the plan more acceptable to affected residents. In addition, safety provisions, such as gradual slopes and a rapid dewatering time must be incorporated.

3. Stormwater Detention Chamber at Kohl's Parking Lot

The Midvale Boulevard/University Avenue intersection and the Kohl's parking lot are located in a low-lying area. This area is densely developed at present, and the value of

this land is very high. Therefore, provision of surface stormwater detention is not a feasible alternative. Instead, to provide a substantial amount of detention, it would be necessary to construct an underground storage chamber. The most practical location for this chamber would be under the Kohl's parking lot, having "footprint" dimensions of approximately 200 feet by 300 feet (1.4 acres). Provision of an adequate storage volume would require excavation to significant depths. A pumping station would be necessary to drain the chamber and keep it dry between storm events.

Hydraulic analysis indicates that under existing conditions, approximately 72 acre-feet of stormwater would discharge from the system for a 100-year storm frequency. Therefore, a storage chamber having a capacity of 72 acre-feet would be necessary to reduce the stormwater discharge to the capacity of the downstream system. With a 1.4 acre footprint, this would require a chamber having a depth of approximately 51 feet. Preliminary calculations indicate that such a structure would cost in excess of $16,000,000.

Based upon this analysis, it is evident that provision of a stormwater detention chamber would not be a cost effective method of alleviating existing flooding. Provision of a smaller chamber in combination with additional detention in the watershed and/or in combination with construction of a relief sewer may be feasible.

B. Stormwater Conveyance Components

1. Relief Sewer to Willow Creek Outlet

Conveyance components evaluated involve increasing the conveyance capability of the existing box culvert from the Midvale/University intersection easterly to the existing outlet at Willow Creek. This would be accomplished by constructing a new box culvert parallel to the existing box culvert to increase the conveyance capacity to a level which would alleviate upstream flooding. Hydraulic calculations indicate that to accomplish this, a twelve foot wide by six foot high box culvert would be required. The most feasible location of this culvert would be along the existing culvert alignment from the Midvale/University intersection, easterly to approximately Farley Avenue. East of Farley Avenue, the culvert would be located along Chicago, Milwaukee, St. Paul, and Pacific Railroad right-of-way, north of Campus Drive. As discussed in previous studies by the City of Madison, numerous conflicts are likely along this route, including existing utilities, disruption to traffic, and construction under existing pavement. In addition, if the route along the railroad tracks were selected, coordination with the railroad and construction directly adjacent to the railroad tracks would be necessary. To protect the railroad tracks and sewer trench adequately, sheet pile may be required, adding to the construction cost. The proposed culvert would have to cross Walnut Drive, which may be difficult, given the low available clearance.

Other relief sewer routes considered are described below:

a. Consideration was given to intercepting excess stormwater discharge on Midvale Boulevard at Heather Crest Drive, one block north of Regent Street. A new relief sewer would be constructed easterly along Heather Crest Drive, northerly along Owen and Blackhawk, and easterly along Harvey Street to Ridge Street. The relief sewer would connect to the existing culvert at Ridge Street and University Avenue.

It was concluded that this alternative is not desirable because, while it would alleviate flooding at the University/Midvale intersection, it may significantly increase flooding potential along low lying points north of University Avenue east of Ridge Street. This is because flooding at University/Midvale presently acts as stormwater detention, reducing peak discharges through the culvert east of the flooded area. Since the existing culvert east of the Midvale/University intersection does not have sufficient capacity to carry a 100-year storm peak discharge, connecting a relief sewer to the existing culvert would force additional discharge through a culvert flowing at capacity, thus causing the culvert to surcharge onto adjacent lands.

b. Consideration was also given to constructing a relief sewer along the existing culvert route, as described in Section B, above. However, instead of routing the culvert easterly along the Chicago, Milwaukee, St. Paul and Pacific Railroad tracks east of Farley Avenue, the culvert would be routed easterly along University Avenue, parallel to the existing culvert. This route is not recommended because there would be a greater number of utility conflicts and easements would probably be necessary since University Avenue is relatively narrow. Also, this route would cause a significant disruption to traffic along University Avenue.

C. Diversion Components

1. Blackhawk Relief Tunnel

A report titled "University Avenue-West End Relief Storm Sewer, Report No. 2" prepared by the Engineering Division of the City of Madison in 1965 investigated construction of the "Blackhawk Relief Tunnel" from the University/Midvale intersection to a new outlet at Lake Mendota, via a new tunnel across Blackhawk Country Club. Proposed work included the following:

a. Construction of 2,300 feet of 78-inch storm sewer by tunneling.

b. Construction of 800 feet of 78-inch storm sewer by open trench methods.

c. Construction of 850 feet of 48-inch storm sewer to serve the Hill Farms/Hilldale Shopping Center area.

The proposed storm sewer would be designed to provide a ten year level of protection to the area.

Findings of the report were as follows:

a. Results of a geological investigation underneath Blackhawk Country Club indicated that the tunnel would be in Franconia Sandstone, making conditions favorable for tunneling.

b. The route lies entirely within the Village of Shorewood Hills.

c. Due to the depth of the tunnel, relocation and reconnection of existing utilities should be minimal.

d. This alternative should not cause disruption of traffic or utility service.

For the 1997 study, the Blackhawk Relief Tunnel alternative has been reconsidered in light of its favorable consideration in the 1965 report. Findings of this investigation are summarized below:

a. The proposed work required would include the following:

1) Construction of a junction chamber at the Midvale/University intersection to divert culvert flow in excess of the existing culvert capacity (approximately 350 cfs).

2) Construction of a box culvert westerly from the junction chamber to Burbank Place, then northerly along Burbank Place to Locust Drive, then westerly along Locust Drive approximately 400 feet. From this point, a tunnel approximately 2,300 feet in length would be constructed in a northwesterly direction under Blackhawk Country Club. The tunnel would outlet to Lake Mendota at the marina. Construction of tunneling shafts allows tunneling equipment to be lowered to the level of construction. These shafts would become permanent junction chambers once tunneling operations are complete.

3) An outlet structure would be constructed at the marina to dissipate energy. Restoration of the marina and shoreline would be completed.

4) Special inlet structures would be constructed at low points near, and north of, the University/Midvale intersection to intercept surface flow so that the 100-year storm flow is collected.

5) Restoration of streets and terraces, including the University/Midvale intersection, Burbank Place, and Locust Street, would be completed. Utility relocations along Burbank Place would likely be necessary.

b. The 1965 report considered construction of a 78-inch tunnel. This design would provide a ten-year level of protection. As previously discussed, because homes, businesses, and two major arterial roadways are threatened with recurrent flooding, the design criteria for this study is the 100-year storm. To provide a 100-year level of protection to the adjacent area, a 108-inch diameter tunnel would be necessary. This tunnel diameter could be reduced by providing stormwater detention either in the watershed or in an underground chamber in the Kohl's parking lot. The cost difference for tunneling varying pipe sizes is not significant. A cost analysis of various combinations of alternative components is discussed in Section 4.04.

D. Floodproofing

A potentially lower cost alternative to construction of flood relief or storage structures may be floodproofing the Garden Homes Subdivision. Floodproofing would provide a 100-year level of structural protection to properties in the Garden Homes Subdivision. However, standing water may still be present immediately following heavy rains. Also, floodproofing would not alleviate existing flooding at the Kohl's development, the University/Midvale intersection, or other locations to the east.

Two approaches to floodproofing were considered for this project. One approach is to construct a combination levee/storage/pumping system to isolate the entire Garden Homes Subdivision from the trunk drainage system. A second approach is to make structural improvements to individual homes to prevent entry of stormwater during flood events. These approaches are discussed in greater detail in Sections 4.04 B.13 and 4.04 B.14.

4.04 STORMWATER MANAGEMENT ALTERNATIVES

A. General

To determine the most cost-effective stormwater management plan, 14 alternatives consisting of various combinations of individual stormwater management components discussed in Section 4.03 were developed.

Approximate opinions of probable costs for each of the alternative components were developed. The overall alternative cost was determined by the sum of the approximate costs of individual alternative components, plus an adjustment factor for engineering and contingencies. Descriptions of various alternatives analyzed are provided below. Each alternative should provide a 100-year level of protection, except where indicated.

Table 4.04 summarizes alternatives analyzed, and includes opinions of probable cost for each alternative.

Alternative	Blackhawk Relief Tunnel Diameter	Stormwater Detention Volume (Ac-ft) Kohl's	Rennebohm Park	Lucia Crest Park	Willow Creek Relief Sewer	Flood Proofing	Alternative Cost
A-1	108"	0	Existing	0	N/A	N/A	$6,739,000
A-2	96"	14.2	Existing	0	N/A	N/A	$13,472,000
A-3	96"	7.0	18	0	N/A	N/A	$10,630,000
A-4	72"	40.8	Existing	0	N/A	N/A	$23,027,000
A-5	0	71.5	Existing	0	N/A	N/A	$21,630,000
A-6	0	62.5	18	0	N/A	N/A	$21,751,000
A-7	0	26.3	18	20	N/A	N/A	$14,195,000
A-8	96"	0	Existing	20	N/A	N/A	$7,742,000
A-9	72"	3.8	Existing	20	N/A	N/A	$9,163,000
A-10	96"	0	18	20	N/A	N/A	$8,155,000
A-11	72"	2.2	18	20	N/A	N/A	$8,653,000
A-12	0	0	Existing	0	12' x 6'	N/A	$19,342,000
A-13 *	0	0	Existing	0	N/A	YES	$2,099,000
A-14 *	0	0	Existing	0	N/A	YES	$1,890,000

*Note: Alternatives A-13 and A-14 do not provide a 100-year level of protection to areas outside the Garden Homes neighborhood.

Table 4.04 Description of Alternatives

B. Stormwater Management Alternatives

1. Alternative A-1 - Blackhawk Relief Tunnel, 108-inch Diameter

Alternative A-1 includes construction of the Blackhawk Relief Tunnel sized to convey the entire excess peak discharge for a 100-year storm event. Hydraulic modeling results indicate that this would require a 108-inch diameter tunnel under the country club, and an eleven foot wide by six foot high box culvert in open cut areas. Construction would include junction chambers, an energy dissipator, special inlets, tunneling shafts, and surface restoration, as described in Section 4.03 and depicted in Figure 4.04-1.

The probable cost of Alternative A-1 is $6,739,000, including engineering and contingencies. A breakdown of this opinion of probable cost is included in Table 4.04-1.

Item	Unit	Quantity	Unit Cost	Cost
R.C. Box Culvert, 11' x 6'	LF	1,300	$700	$910,000
Restoration	LS	1	$60,000	$60,000
Junction Chamber	EA	3	$25,000	$75,000
Tunneled Pipe, 108"	LF	2,300	$1,500	$3,450,000
Tunnel Shafts	LF	32	$4,000	$128,000
Energy Dissipator/Shoreline Restoration	LS	1	$180,000	$180,000
Special Inlet Construction	LS	1	$100,000	$100,000
Rock Excavation	LS	1	$89,000	$89,000
Subtotal				$4,992,000
Engineering/Contingencies (35%)				$1,747,200
Grand Total				$6,739,200

Table 4.04-1 Alternative A-1 Blackhawk Relief Sewer, 108 Inch Opinion of Probable Cost

2. Alternative A-2 - Blackhawk Relief Tunnel, 96-inch Diameter/Kohl's Detention Storage

Alternative A-2 includes construction of the Blackhawk Relief Tunnel sized to convey a portion of the excess peak discharge for a 100-year storm event, with the remainder being stored in a detention chamber in the Kohl's parking lot. For this alternative, a 96-inch tunnel would be constructed under the country club, with the open trench portions being a ten foot wide by 5 foot high box culvert. Relief tunnel construction would include junction chambers, an energy dissipator, special inlets, and surface restoration, as described in Section 4.03. Hydraulic modeling indicates that with a 96-inch tunnel, an excess stormwater volume of 14.2 acre-feet would continue to overflow the

drainage system. To store this excess volume, a 200 foot by 300 foot underground detention chamber, approximately 10 feet in depth would be constructed under the Kohl's parking lot. A pumping station would be required to dewater the detention chamber after and between storm events.

Item	Unit	Quantity	Unit Cost	Cost
R.C. Box Culvert, 10' x 5'	LF	1,300	$600	$780,000
Restoration	LS	1	$60,000	$60,000
Junction Chamber	EA	3	$25,000	$75,000
Tunneled Pipe, 96"	LF	2,300	$1,500	$3,450,000
Tunnel Shafts	LF	32	$4,000	$128,000
Energy Dissipator/Shoreline Restoration	LS	1	$180,000	$180,000
Special Inlet Construction	LS	1	$100,000	$100,000
Rock Excavation	LS	1	$89,000	$89,000
Underground Storage Chamber/ Pumping Station	LS	1	$5,117,000	$5,117,000
Subtotal				$9,979,000
Engineering/Contingencies (35%)				$3,492,650
Grand Total				$13,471,650

Table 4.04-2 Alternative A-2 - Blackhawk Relief Sewer, 96-inch Kohl's Detention, Opinion of Probable Cost

The probable cost of Alternative A-2 is $13,472,000, including engineering and contingencies. A breakdown of this opinion of probable cost is included in Table 4.04-2.

3. Alternative A-3 - Blackhawk Relief Tunnel, 96-inch Diameter/Stormwater Detention at Rennebohm Park and Kohl's Parking Lot

Alternative A-3 includes the following:

a. Construction of a retention basin at Rennebohm Park to reduce the peak discharge to the Midvale/University intersection. This basin would have a total storage capacity of approximately 18 acre-feet.

b. Construction of the Blackhawk Relief Tunnel sized to convey a portion of the excess peak discharge for a 100-year storm event. For this alternative, a 96-inch tunnel would be constructed under the country club, with the open trench portions being a ten foot wide by 5 foot high box culvert. Relief tunnel construction would include junction chambers, an energy dissipator, special inlets, and surface restoration, as described in Section 4.03.

c. Hydraulic modeling indicates that with a 96-inch tunnel and 18 acre-feet of detention storage at Rennebohm Park, an excess stormwater volume of 7.0 acre-feet would continue to overflow the drainage system. To store this excess volume, a 200 foot by 150 foot underground detention chamber, approximately 10 feet in depth would be constructed under the Kohl's parking lot. A pumping station would be required to dewater the detention chamber after and between storm events.

The probable cost of Alternative A-3 is $10,630,000, including engineering and contingencies. A breakdown of this opinion of probable cost is included in Table 4.04-3.

Item	Unit	Quantity	Unit Cost	Cost
R.C. Box Culvert, 10' x 5'	LF	1,300	$600	$780,000
Restoration	LS	1	$60,000	$60,000
Junction Chamber	EA	3	$25,000	$75,000
Tunneled Pipe, 96"	LF	2,300	$1,500	$3,450,000
Tunnel Shafts	LF	32	$4,000	$128,000
Energy Dissipator/Shoreline Restoration	LS	1	$180,000	$180,000
Special Inlet Construction	LS	1	$100,000	$100,000
Rock Excavation	LS	1	$89,000	$89,000
Underground Storage Chamber/ Pumping Station	LS	1	$5,117,000	$5,117,000
Rennebohm Park Detention	LS	1	$306,200	$306,200
Subtotal				$7,874,200
Engineering/Contingencies (35%)				$2,755,970
Grand Total				$10,630,170

Table 4.04-3 Alternative A-3 - Blackhawk Relief Sewer, 96-inch Kohl's Detention, Opinion of Probable Cost

4. Alternative A-4 - Blackhawk Relief Tunnel, 72-inch/Kohl's Detention Storage

Alternative A-4 includes construction of the Blackhawk Relief Tunnel sized to convey a portion of the excess peak discharge for a 100-year storm event, with the remainder being stored in a detention chamber in the Kohl's parking lot. For this alternative, a 72-inch tunnel would be constructed under the country club, with the open trench portions being a 72-inch reinforced concrete pipe. Relief tunnel construction would include junction chambers, an energy dissipator, special inlets, and surface restoration, as described in Section 4.03. Hydraulic modeling indicates that with a 72-inch tunnel, an excess stormwater volume of 40.8 acre-feet would continue to overflow the drainage system. To store this excess volume, a 200 foot by 300 foot underground detention chamber, approximately 30 feet in depth would be constructed under the Kohl's parking

lot. A pumping station would be required to dewater the detention chamber after and between storm events.

The probable cost of Alternative A-4 is $23,027,000, including engineering and contingencies. A breakdown of this opinion of probable cost is included in Table 4.04-4.

Item	Unit	Quantity	Unit Cost	Cost
72" RCP - Open Cut	LF	1,300	$150	$195,000
Restoration	LS		$60,000	$60,000
Junction Chamber	EA	3	$25,000	$75,000
Tunneled Pipe, 72"	LF	2,300	$1,500	$3,450,000
Tunnel Shafts	LF	32	$4,000	$128,000
Energy Dissipator/Shoreline Restoration	LS	1	$180,000	$180,000
Special Inlet Construction	LS	1	$100,000	$100,000
Rock Excavation	LS	1	$89,000	$89,000
Underground Storage Chamber/ Pumping Station	LS	1	$5,117,000	$5,117,000
Subtotal				$9,979,000
Engineering/Contingencies (35%)				$3,492,650
Grand Total				$13,471,650

Table 4.04-4 Alternative A-4- Blackhawk Relief Sewer, 72-inch Kohl's Detention, Opinion of Probable Cost

5. Alternative A-5 - Provide Detention Storage at Kohl's Parking Lot Only

Alternative A-5 includes construction of an underground detention chamber to store the

Item	Unit	Quantity	Unit Cost	Cost
Roof Slab	SF	60,000	$25	$1,500,000
Base Slab	CY	6,666	$260	$1,733,160
Walls	CY	5,778	$575	$3,322,350
Columns	LS	1	$2,000,000	$2,000,000
Excavation	CY	163,100	$25	$4,077,500
Dewater	LS	1	$1,500,000	$1,500,000
Rock Anchors	LS	1	$1,800,000	$1,800,000
Backfill	CY	9,030	$20	$89,000
Subtotal				$16,022,010
Engineering/Contingencies (35%)				$5,607,704
Grand Total				$21,629,714

Table 4.04-5 Alternative 5 - Stormwater Detention Chamber at Kohl's Only - Opinion of Probable Cost

entire stormwater volume in excess of the capacity of the existing culvert. Hydraulic and hydrologic modeling indicates that a chamber having a capacity of approximately 71.5 acre-feet of storage volume would be required. This chamber would have dimensions of approximately 200 feet by 300 feet, and a depth of approximately 50 feet.

The probable cost of Alternative A-5 is $21,630,000, including engineering and contingencies. A breakdown of this opinion of probable cost is shown in Table 4.04-5.

6. Alternative A-6 - Provide Detention Storage at Kohl's Parking Lot and Rennebohm Park

Alternative A-6 includes construction of a retention basin at Rennebohm Park to reduce the peak discharge rate to the Midvale/University intersection, and construction of an underground detention facility at the Kohl's Parking Lot to store the remaining excess stormwater volume. The Rennebohm Park detention pond would have a total storage capacity of approximately 18 acre-feet. Hydraulic and hydrologic modeling indicates that a chamber having a capacity of approximately 62.5 acre-feet of storage volume would be required at the Kohl's Parking Lot, in this case. This chamber would have dimensions of approximately 200 feet by 300 feet, and a depth of approximately 45 feet.

The probable cost of Alternative A-6 is $21,751,000, including engineering and contingencies. A breakdown of this opinion of probable cost is shown in Table 4.04-6.

Item	Unit	Quantity	Unit Cost	Cost
Underground Detention Chamber	LS	1	$15,806,000	$15,806,000
Rennebohm Park Detention	LS	1	$306,200	$306,200
Subtotal				$16,112,200
Engineering/Contingencies (35%)				$5,639,270
Grand Total				$21,751,470

Table 4.04-6 Alternative A-6 - Stormwater Detention at Kohl's Parking Lot / Rennebohm Park - Opinion of Probable Cost

7. Alternative A-7 - Provide Detention Storage at Kohl's Parking Lot, Rennebohm Park, and Lucia Crest Park

Alternative A-7 includes construction of detention/retention basins at Rennebohm Park and Lucia Crest Park to reduce the peak discharge rate to the Midvale/University intersection, and construction of an underground detention facility at the Kohl's Parking Lot to store the remaining excess stormwater volume. The Rennebohm Park detention pond would have a total storage capacity of approximately 18 acre-feet. The Lucia Crest

Park detention pond would have a capacity of approximately 20 acre-feet. Hydraulic and hydrologic modeling indicates that a chamber having a capacity of approximately 26.3 acre-feet of storage volume would be required at the Kohl's Parking Lot, in this case. This chamber would have dimensions of approximately 200 feet by 300 feet, and a depth of approximately 19 feet.

The probable cost of Alternative A-7 is $14,195,000, including engineering and contingencies. A breakdown of this opinion of probable cost is shown in Table 4.04-7.

Item	Unit	Quantity	Unit Cost	Cost
Underground Detention Chamber	LS	1	$9,336,000	$9,336,000
Rennebohm Park Detention	LS	1	$306,200	$306,200
Lucia Crest Park Detention	LS	1	$872,500	$872,500
Subtotal				$10,514,700
Engineering/Contingencies (35%)				$3,680,145
Grand Total				$14,194,845

Table 4.04-7 Alternative A-7 - Stormwater Detention at Kohl's, Rennebohm Park, and Lucia Crest Park - Opinion of Probable Cost

8. Alternative A-8 - Blackhawk Relief Sewer, 96-Inch/Lucia Crest Park Detention

Alternative A-8 includes construction of a detention basin in Lucia Crest Park to reduce the peak discharge to the Midvale/University intersection, along with construction of the

Item	Unit	Quantity	Unit Cost	Cost
R.C. Box Culvert, 10' x 5'	LF	1,300	$600	$780,000
Restoration	LS	1	$60,000	$60,000
Junction Chamber	EA	3	$25,000	$75,000
Tunneled Pipe, 96"	LF	2,300	$1,500	$3,450,000
Tunnel Shafts	LF	32	$4,000	$128,000
Energy Dissipator/ Shoreline Restoration	LS	1	$180,000	$180,000
Special Inlet Construction	LS	1	$100,000	$100,000
Rock Excavation	LS	1	$89,000	$89,000
Lucia Crest Park Detention	LS	1	$872,500	$872,500
Subtotal				$5,734,500
Engineering/Contingencies (35%)				$2,007,075
Grand Total				$7,741,575

Table 4.04-8 Alternative A-8 - Blackhawk Relief Sewer, 96-inch Lucia Crest Detention - Opinion of Probable Cost

Blackhawk Relief Tunnel. For this alternative, a 96-inch tunnel would be constructed under the country club, with the open trench portions being a ten foot wide by 5 foot high box culvert. Relief tunnel construction would include junction chambers, an energy dissipator, special inlets, and surface restoration, as described in Section 4.03. Hydraulic modeling indicates that with a 96-inch tunnel and detention at Lucia Crest Park, the 100-year design criteria would be achieved without provision of additional storage in the Kohl's Parking Lot.

The probable cost of Alternative A-8 is $7,742,000, including engineering and contingencies. A breakdown of this opinion of probable cost is shown in Table 4.04-8.

9. Alternative A-9 - Blackhawk Relief Sewer, 72-inch/Detention at Lucia Crest Park and Kohl's Parking Lot

Alternative A-9 is identical to Alternative A-8, except the proposed Blackhawk Relief Tunnel diameter would be 72 inches rather than 96 inches in diameter. This would cause an excess stormwater volume of 3.8 acre-feet from the system. To accommodate this excess volume, a detention chamber would be constructed in the Kohl's parking lot. This chamber would have dimensions of approximately 130 feet by 130 feet by 10 feet deep.

The probable cost of Alternative A-9 is $9,163,000, including engineering and contingencies. A breakdown of this opinion of probable cost is shown in Table 4.04-9.

Item	Unit	Quantity	Unit Cost	Cost
72" RCP - Open Trench	LF	1300	$150	$195,000
Restoration	LS	1	$60,000	$60,000
Junction Chamber	EA	3	$25,000	$75,000
Tunneled Pipe, 72"	LF	2300	$1,500	$3,450,000
Tunnel Shafts	LF	32	$4,000	$128,000
Energy Dissipator/ Shoreline Restoration	LS	1	$180,000	$180,000
Special Inlet Construction	LS	1	$100,000	$100,000
Rock Excavation	LS	1	$89,000	$89,000
Underground Storage Chamber/Pumping Station	LS	1	$1,638,000	$1,638,000
Lucia Crest Park Detention	LS	1	$872,500	$872,500
Subtotal				$6,787,500
Engineering/Contingencies (35%)				$2,375,625
Grand Total				$9,163,125

Table 4.04-9 **Alternative A-9 - Blackhawk Relief Sewer, 72-inch Kohl's Detention / Lucia Crest Park Detention - Opinion of Probable Cost**

10. Alternative A-10 - Blackhawk Relief Sewer, 96-inch/Detention at Lucia Crest Park and Rennebohm Park

Alternative A-10 includes construction of retention/detention basins in Lucia Crest Park and Rennebohm Park to reduce the peak discharge to the Midvale/University intersection, along with construction of the Blackhawk Relief Tunnel. For this alternative, a 96-inch tunnel would be constructed under the country club, with the open trench portions being a ten foot wide by 5 foot high box culvert. Relief tunnel construction would include junction chambers, an energy dissipator, special inlets, and surface restoration, as described in Section 4.03. Hydraulic modeling indicates that with a 96-inch tunnel and detention at Lucia Crest Park and Rennebohm Park, the 100-year design criteria would be achieved without provision of additional storage in the Kohl's Parking Lot.

The probable cost of Alternative A-10 is $8,155,000, including engineering and contingencies. A breakdown of this opinion of probable cost is shown in Table 4.04-10.

Item	Unit	Quantity	Unit Cost	Cost
R.C. Box Culvert, 10' x 5'	LF	1300	$600	$780,000
Restoration	LS	1	$60,000	$60,000
Junction Chamber	EA	3	$25,000	$75,000
Tunneled Pipe, 96"	LF	2300	$1,500	$3,450,000
Tunnel Shafts	LF	32	$4,000	$128,000
Energy Dissipator/ Shoreline Restoration	LS	1	$180,000	$180,000
Special Inlet Construction	LS	1	$100,000	$100,000
Rock Excavation	LS	1	$89,000	$89,000
Rennebohm Park Detention	LS	1	$306,200	$306,200
Lucia Crest Park Detention	LS	1	$872,500	$872,500
Subtotal				$6,040,700
Engineering/Contingencies (35%)				$2,114,245
Grand Total				$8,154,945

Table 4.04-10 Alternative A-10 - Blackhawk Relief Sewer, 96-inch Rennebohm Park Detention / Lucia Crest Detention - Opinion of Probable Cost

11. Alternative A-11 - Blackhawk Relief Sewer, 108-inch/Detention at Lucia Crest Park, Rennebohm Park, and Kohl's Parking Lot

Alternative A-11 is identical to Alternative A-10, except the proposed Blackhawk Relief Tunnel diameter would be 72 inches rather than 96 inches in diameter. This would

cause an excess stormwater volume of 2.2 acre-feet from the system. To accommodate this excess volume, a detention chamber would be constructed in the Kohl's parking lot. This chamber would have dimensions of approximately 90 feet by 90 feet by 12 feet deep.

The probable cost of Alternative A-11 is $8,653,000, including engineering and contingencies. A breakdown of this opinion of probable cost is shown in Table 4.04-11.

Item	Unit	Quantity	Unit Cost	Cost
72" RCP - Open Cut	LF	1300	$150	$195,000
Restoration	LS	1	$60,000	$60,000
Junction Chamber	EA	3	$25,000	$75,000
Tunneled Pipe, 96"	LF	2300	$1,500	$3,450,000
Tunnel Shafts	LF	32	$4,000	$128,000
Energy Dissipator/ Shoreline Restoration	LS	1	$180,000	$180,000
Special Inlet Construction	LS	1	$100,000	$100,000
Rock Excavation	LS	1	$89,000	$89,000
Underground Storage Chamber/Pumping Station	LS	1	$954,000	$954,000
Rennebohm Park Detention	LS	1	$306,200	$306,200
Lucia Crest Park Detention	LS	1	$872,500	$872,500
Subtotal				$6,409,700
Engineering/Contingencies (35%)				$2,243,395
Grand Total				$8,653,095

Table 4.04-11 Alternative A-11 - Blackhawk Relief Sewer, 72-inch Kohl's Detention / Rennebohm Park Detention / Lucia Crest Park Detention - Opinion of Probable Cost

12. Alternative A-12 - Relief Storm Sewer to East

Alternative A-12 includes construction of a new relief conduit easterly to the existing outlet at Willow Creek. The new conduit would consist of a twelve foot wide by six foot high box culvert. The culvert would be constructed generally parallel with the existing culvert easterly to Farley Avenue. East of Farley Avenue, the culvert would generally follow the Chicago, Milwaukee, St. Paul, and Pacific Railroad right-of-way to the existing outlet at Willow Creek. Necessary work would include construction of approximately 8,500 feet of box culvert, utility relocation, construction of a junction chamber at the University/Midvale intersection, restoration of streets, and reconstruction of the outlet at Willow Creek.

The probable cost of Alternative A-12 is $19,342,000, including engineering and contingencies. A breakdown of this opinion of probable cost is shown in Table 4.04-12.

Item	Unit	Quantity	Unit Cost	Cost
R.C. Box Culvert, 12' x 6'	LF	8,475	$800	$6,780,000
Restoration	LF	8,475	$100	$847,500
Jctn Chambers/Connections	EA	10	$50,000	$500,000
Outlet Structure/Shore Rest.	LS	1	$100,000	$100,000
Utility Relocation	LS	1	$800,000	$800,000
Sheet Pile	LS	1	$200,000	$200,000
Special Inlet Construction	LS	1	$100,000	$100,000
Underground Storage Chamber	LS	1	$5,000,000	$5,000,000
Subtotal				$14,327,500
Engineering/Contingencies (35%)				$5,014,625
Grand Total				$19,342,125

Table 4.04-12 Alternative A-12 - Relief Sewer to Willow Creek Outlet - Opinion of Probable Cost

13. Alternative A-13 - Floodproof Garden Homes Subdivision

Alternative A-13 includes construction of a combination levee/berm/pumping system to isolate the Garden Homes Subdivision from the existing drainage system. This construction would create an "island" of dry land from the west line of the Kohl's development to Maple Terrace from east to west, and from University Avenue to Locust Drive, from south to north.

To accomplish this, the following work would be necessary:

a. A berm or wall would be constructed adjacent to the Kohl's development and along University Avenue to Burbank Place to prevent stormwater in the Kohl's parking lot and University/Midvale intersection from overflowing into the subdivision. This berm or wall would have a maximum height of three to five feet.

b. An underground storage reservoir and pumping station would be constructed underneath Burbank Place to hold drainage from inside the bermed area. The storage reservoir would be sized to hold the entire stormwater runoff volume within the Garden Homes subdivision for the 100-year storm event. A submersible pumping station would be constructed to dewater the reservoir after the mainline culvert has drained.

c. An additional levee and stormwater pumping station would likely be necessary to intercept stormwater from the office complex immediately west of the subdivision. This pumping station would force stormwater flow into the mainline culvert downstream from the subdivision.

d. Water, sanitary sewers, and other utilities would be relocated under Burbank Place to accommodate the storage reservoir.

e. Burbank Place would be reconstructed after installation of the underground reservoir.

Potential problems with this alternative, include:

a. This alternative would not improve the flooding situation downstream. In fact, it may aggravate flooding due to the loss of stormwater storage volume in the Garden Homes area.

b. Flooding problems due to seepage, particularly for properties adjacent to the Kohl's development may continue.

c. The underground storage chambers and pumping stations would have relatively high annual maintenance costs.

The probable cost of Alternative A-13 is $2,099,000, including engineering and contingencies. A breakdown of this cost is included in Table 4.04-13.

Item	Unit	Quantity	Unit Cost	Cost
Berm/Wall at Kohl's	LS	1	$80,000	$80,000
10' x 5' Box Culvt Sections for Underground Storage	LF	1,000	$600	$600,000
Utility Relocation	LS	1	$50,000	$50,000
Street Restoration	LF	600	$125	$75,000
Junctions/Connections	LS	1	$50,000	$50,000
Pumping Station for Garden Homes	LS	1	$200,000	$200,000
Pumping/Storage/Levee For Office Bldgs. To West	LS	1	$500,000	$500,000
Subtotal				$1,555,000
Engineering/Contingencies (35%)				$544,250
Grand Total				$2,099,250

Table 4.04-13 Alternative A-13 - Floodproof Existing Garden Homes - Opinion of Probable Cost

14. Alternative A-14 - Floodproof Individual Homes

Alternative 14 includes floodproofing individual homes in the Garden Homes Subdivision, rather than isolating the entire subdivision. This work would involve raising the homes and reconstructing foundations. Furnaces, water heaters, electrical services, and other utilities would be relocated from basements, where necessary, and relocated above ground. To do this, ground floor additions onto existing homes would be constructed. This work has been performed and funded by the Federal Emergency Management Agency in a number of other floodplain areas throughout the country.

Potential problems with this alternative, include:

a. This alternative would alleviate the likelihood of structural and property damages to homes in the Garden Homes Subdivision in the event of a 100-year storm. However, the Kohl's development, the University/Midvale intersection, and other locations to the east would see no benefit from this work.

b. This alternative would not prevent the occurrence of standing water and associated health and safety hazards following heavy rainfall events in the Garden Homes subdivision and adjacent areas.

The probable cost of Alternative A-14 is $1,890,000, including engineering and contingencies. A breakdown of this cost is included in Table 4.04-14.

Item	Unit	Quantity	Unit Cost	Cost
COST PER HOME	LS	35	$40,000	$1,400,000
Subtotal				$1,400,000
Engineering/Contingencies (35%)				$490,000
Grand Total				$1,890,000

Table 4.04-14 Alternative A-14 - Floodproof Individual Homes

4.05 DISCUSSION OF ALTERNATIVES

A. Comparison of Alternative Costs

Table 4.03-1 indicates a wide range in probable costs for Alternatives A-1 through A-14. The lowest cost alternative evaluated was $1,890,000 for floodproofing individual homes. However, this alternative would also provide the least overall benefit since it would continue to allow flooding of the Kohl's Shopping Center site and other points eastward. The lowest

cost alternative which will provide a 100-year level of protection is Alternative A-1, construction of a 108-inch Blackhawk Relief Tunnel.

Overall, the most expensive alternatives are those including construction of an underground storage chamber in the Kohl's Parking Lot. This is because the structure would have to be extremely large and as deep as 50 feet to have sufficient capacity to significantly reduce peak discharge rates. Also, Alternative A-12, construction of a relief culvert eastward to Willow Creek is prohibitively expensive due to the size and length of the culvert required and the potential conflicts encountered.

Based on this discussion, only the following alternatives appear to be viable from a cost-effectiveness standpoint:

	Relief Tunnel Diameter	Kohl's Detention	Rennebohm Park Detention	Lucia Crest Park Detention	Alternative Cost
A-1	108"	0	Existing	0	$6,739,000
A-8	96"	0	Existing	20	$7,742,000
A-9	72"	3.8	Existing	20	$9,163,000
A-10	96"	0	18	20	$8,155,000
A-11	72"	2.2	18	20	$8,653,000
A-13	0	0	Existing	0	$2,099,000
A-14	0	0	Existing	0	$1,890,000

Except for Alternatives A-1, A-13, and A-14, each of these alternatives would involve a potential loss of park lands at either Rennebohm Park and/or Lucia Crest park. Procurement of these lands for stormwater detention could be difficult and unpopular. Alternatives A-13 and A-14, as discussed, would not provide a 100-year level of protection for areas outside the Garden Homes subdivision.

B. Recommended Alternative

Alternative A-1, construction of a 108-inch Blackhawk Relief Tunnel, is the recommended alternative for alleviating flooding at the Midvale Boulevard/University Avenue intersection. The justification for this recommendation is:

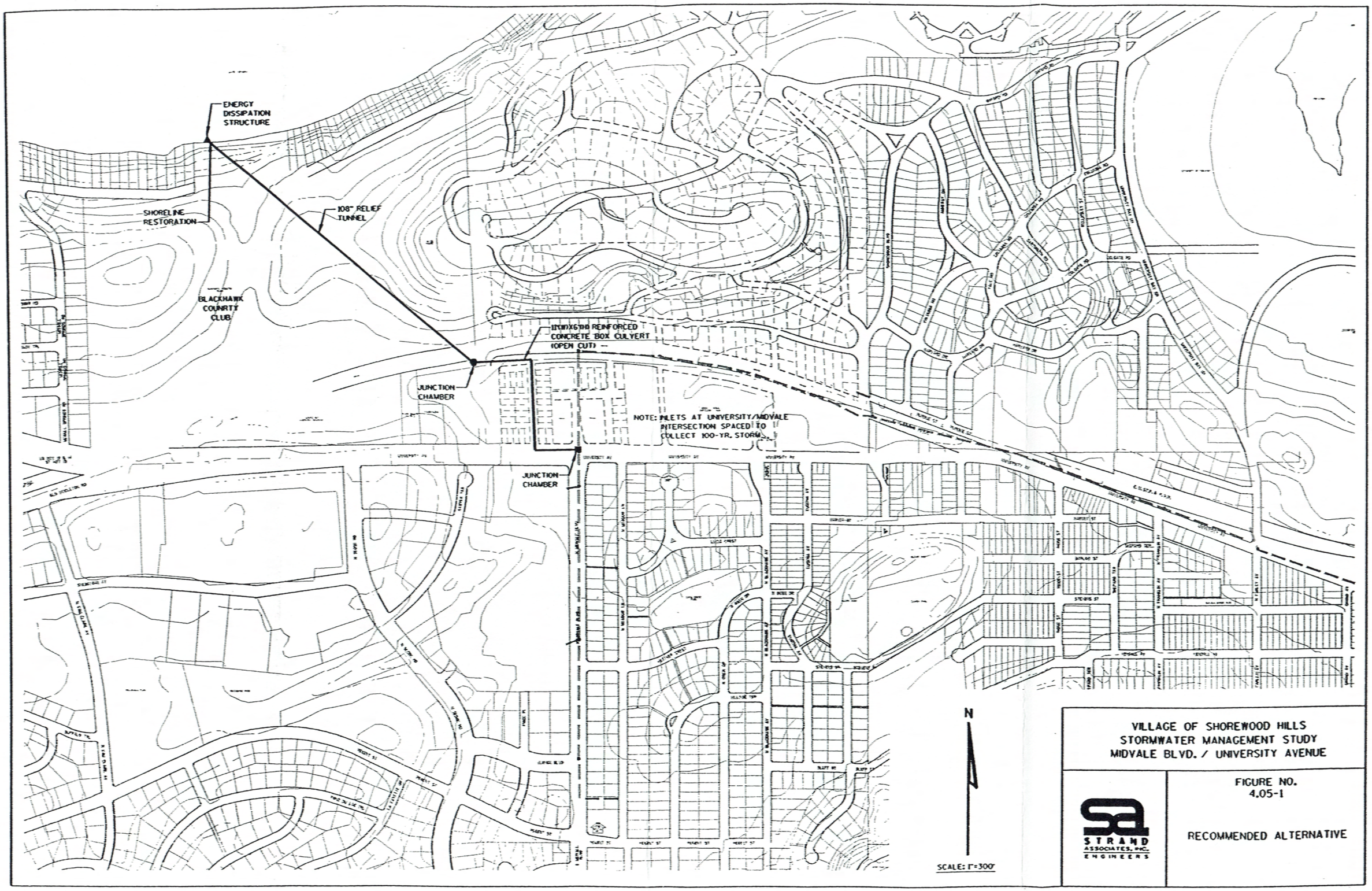
1. It appears to be the lowest cost alternative for providing a 100-year level of protection, in accordance with design criteria.

2. It appears that all work could be performed in public right-of-way (either City of Madison or Village of Shorewood Hills) so that acquisition of private or park lands would not be necessary.

3. There should be a relatively minimal number of utility conflicts.

4. The cost difference for tunneling various pipe sizes is not significant. Therefore, it is prudent to construct the largest practical tunnel to prevent additional work at a later date.

A conceptual drawing of the recommended alternative is included in Figure 4.05-1.


ENERGY DISSIPATION STRUCTURE
SHORELINE RESTORATION
108" RELIEF TUNNEL
BLACKHAWK COUNTRY CLUB
JUNCTION CHAMBER
JUNCTION CHAMBER
NOTE: INLETS AT UNIVERSITY/MIDVALE INTERSECTION SPACED TO COLLECT 100-YR. STORM
N
SCALE: 1"=300'
VILLAGE OF SHOREWOOD HILLS
STORMWATER MANAGEMENT STUDY
MIDVALE BLVD. / UNIVERSITY AVENUE
STRAND ASSOCIATES, INC. ENGINEERS
FIGURE NO.
4.05-1
RECOMMENDED ALTERNATIVE

SECTION 5
CONCLUSIONS AND RECOMMENDATIONS

5.01 CONCLUSIONS

A. The contributing watershed area to this system includes approximately 1,952 acres to the outlet at Willow Creek. Approximately 1,180 acres of this area are directly tributary to the University Avenue/Midvale Boulevard intersection. Approximately 84 percent of the total 1,952 acres lies within the City of Madison, with the remaining portion in the Village of Shorewood Hills.

B. The existing culvert at the intersection has sufficient capacity for approximately 400 cfs. This is less than the cumulative inflow for a 10-year storm event. Fifty-year and 100-year storm events significantly exceed the capacity of the existing culvert, resulting in overflow onto adjacent streets and parking areas.

C. Because the study area is located in a depression, there is no opportunity for overland flow if the capacity of the drainage system is exceeded. Therefore, the culverts serving the area must serve as both the minor and major drainage system. For this reason, stormwater management improvements should provide a 100-year level of protection to the adjacent area.

D. To divert a sufficient amount of stormwater from the project area via a relief tunnel to Lake Mendota, a 108-inch conduit diameter would be necessary. The most likely route would be across Blackhawk Country Club, to the marina.

E. Provision of stormwater detention in the watershed alone cannot sufficiently reduce peak discharges below the capacity of the existing storm sewer system. Provision of stormwater detention at Rennebohm Park and Lucia Crest Park in combination with construction of an underground storage chamber at the Kohl's parking lot could reduce stormwater discharges below the capacity of the existing system. This, however, is not the most cost effective alternative.

F. Construction of a new relief culvert to the existing outlet at Willow Creek is probably not a practical alternative due to the size and length of conduit required, potential utility conflicts, disruption to University Avenue traffic, and other factors.

G. The least expensive alternative evaluated is floodproofing individual homes in the Garden Homes subdivision, at a probable cost of $1,890,000. This alternative would not provide a 100-year level of protection to the Kohl's development, University/Midvale intersection, or points to the east.

H. The most cost-effective alternative which provides a 100-year level of protection to the Garden Homes subdivision, Kohl's Development, and University/Midvale intersection is construction of a 108-inch diameter relief tunnel under Blackhawk Country Club to

Lake Mendota. The probable cost of this alternative is $6,739,000, including engineering and contingencies.

5.02 RECOMMENDATIONS

A. Alternative A-1, construction of a 108-inch Blackhawk Relief Tunnel, is the recommended alternative for alleviating flooding at the Midvale Boulevard/University Avenue intersection. The justification for this recommendation is:

1. It appears to be the lowest cost alternative for providing a 100-year level of protection, in accordance with design criteria.

2. It appears that all work could be performed in public right-of-way (either City of Madison or Village of Shorewood Hills) so that acquisition of private or park lands would not be necessary. Easements for work within the Chicago, Milwaukee, St. Paul, & Pacific railroad right-of-way would be required.

3. There should be a relatively minimal number of utility conflicts.

4. The cost difference for tunneling various pipe sizes is not significant. Therefore, it is prudent to construct the largest practical tunnel to prevent additional work at a later date.

Construction of the Blackhawk Relief Tunnel would include the following:

1. Construction of a diversion structure at the Midvale/University intersection which would direct culvert flow in excess of the existing culvert capacity (approximately 400 cfs) to the new tunnel.

2. Construction of an 11-foot (wide) by 6-foot (high) box culvert westerly from the junction chamber to Burbank Place, then northerly along Burbank Place to Locust Drive, then westerly along Locust Drive approximately 400 feet. From this point, a 108-inch tunnel approximately 2,300 feet in length would be constructed in a northwesterly direction under Blackhawk Country Club. The tunnel would outlet to Lake Mendota at the marina.

3. Construction of an outlet structure at the marina to dissipate energy prior to discharge into Lake Mendota. Restoration of the marina and shoreline would be completed.

4. Special inlet structures would be constructed at low points near, and north of, the University/Midvale intersection to intercept surface flow so that the 100-

year storm flow is collected and transported from the surface to the underground drainage system.

5. Restoration of streets and terraces, including the University/Midvale intersection, Burbank Place, and Locust Street, would be completed. Utility relocations along Burbank Place would likely be necessary.

Completion of this work would upgrade the level of protection of the Kohl's site, Garden Homes subdivision, and adjacent areas from less than a 10-year storm frequency (10 percent annual recurrence probability) to a 100-year storm frequency (1 percent recurrence probability).

B. A cost sharing agreement should be negotiated between the City of Madison and Village of Shorewood Hills to fund project construction. This agreement should be reached within the earliest possible time frame.

C. Coordination with the Wisconsin Department of Natural Resources should be initiated as soon as possible to determine any special requirements for constructing a new outlet to Lake Mendota.

APPENDIX B
RESULTS OF UNDERWATER SURVEY BY DNR

CORRESPONDENCE/MEMORANDUM

State of Wisconsin

DATE: February 16, 2001

FILE REF: [Click **here** and type file ref.]

TO: Ken Johnson, Scot Stewart

FROM: Kurt Welke

SUBJECT: Survey of discharge area – Strand & Assoc. project for Village of Shorewood Hills

On Tuesday 8/22/00 I was accompanied by Joseph Hennessey on a survey of the potential outfall areas for the referenced project. Based on site visits with Strand staff, I conducted a dive survey at the Shorewood Hills Marina (directly below the Blackhawk Country Club 16th Tee), and also at the old Shorewood Beach. Due to the size of the lakefront at each respective site, 3 transects were run at the marina site (east edge of property, central, and west edge) and 1 at the Beach site. Transects were approx. 300' long, extending from shore to the 300' limit.

For the Marina site:
A. Depths were from 0 to 12'.
B. Substrates ranged from clean sand (inshore) to a floculent coarse silt overlying gravel (center of the transects), and terminating with a marl –type bottom. Several large (30'' dia.) boulders were sampled along 2 transects, along with scattered rubble and some woody debris.
C. Vegetation was sampled in all transects, usually beginning inshore with dense Vallisinaria (Wild Celery) beds, with fair amounts of milfoil and small amounts of coontail. By the 200' offshore distance, vegetation was either very sparse or absent.
D. Fish observed included walleye, smallmouth bass, carp and black crappie. I observed 1 mussel.

For the Beach Site:
A. Depth 0 to 17'.
B. Substrate was clean sand from shore to 125' out. From this point to the 300' limit the bottom was marl with a few large boulders present and 1 very large submerged log.
C. Vegetation was similar to the Marina: dense wild Celery from shore to approx. 125' offshore, then sporadic stands of milfoil.
D. I observed smallmouth associated with the log.

My general concern is potential permitting of any further source of direct sedimentation. Any permit (in my estimation) must specify that "in-line" sediment control occurs as well as some sort of "trap" at the terminus. I recommend against any inwater or below surface outfall due to the potential zone of impact, maintenance, and navigation considerations. In my opinion, the best solution still revolves around managing the water before it necessitates conveyance to the lake: IE , infiltration options need to be thoroughly explored.

While the habitat here is typical, usual, and ordinary, it does not therefore become expendable.

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APPENDIX C
SOIL BORINGS

SUBSURFACE INVESTIGATION REPORT
WEST END RELIEF STORM SEWER
BLACKHAWK COUNTRY CLUB AREA
MADISON, WISCONSIN

WARZYN ENGINEERING & SERVICE COMPANY, INC.

P.O. BOX 1031 MADISON 1, WISCONSIN

309 EMIL STREET

TELEPHONE
OFFICE: ALPINE 7-4848

FOUNDATION INVESTIGATIONS
SOIL BORINGS
FIELD & LAB TESTING
FOUNDATION DESIGN
STRUCTURAL DESIGN
SPECIAL PROBLEMS
CONSTRUCTION SUPERVISION

August 20, 1965

City Engineer's Office
City of Madison
City-County Building
Madison, Wisconsin 53709

Attention: Mr. Robert Schoenbeck

Re: West End Relief Sewer under
Blackhawk Country Club
Madison, Wisconsin

Gentlemen:

In accordance with your request, we have performed a subsurface investigation along the proposed 78-inch tunnel that will drain storm water into Lake Mendota. Three (3) copies of our report are attached.

The geologic work and the core borings indicate that this tunnel will be through sandstone of the Franconia formation. It is expected that conditions will change very slightly from one end of the tunnel to the other and no special problems are expected.

If you have questions or comments to make concerning this report, please do not hesitate to contact us. The soil and the rock samples will be sent to you in the near future.

Yours very truly,

WARZYN ENGINEERING & SERVICE CO., INC.

Clifton E. R. Lawson
Professional Engineer

Willard W. Warzyn
Professional Engineer

CERL:mds
Triplicate
Enc

SUBSURFACE INVESTIGATION REPORT
WEST END RELIEF STORM SEWER
BLACKHAWK COUNTRY CLUB AREA
MADISON, WISCONSIN

GENERAL

It is proposed to construct a 78-inch storm sewer from the north end of Midvale Boulevard under Blackhawk Country Club and into Lake Mendota. A section of this sewer alongside the railroad will be built in open cut. However, that section of sewer from the railroad to Lake Mendota will be in tunnel. The tunnel will be approximately 2,000 feet long. It will be as much as 82 feet beneath the surface of the ground between Elevations +25 and +4±.

GEOLOGIC INFORMATION

A geologic study was performed in this area to determine the formations of rock that can be expected during construction. Numerous well logs, geologic maps and rock outcrops were examined by a professional geologist.

The geologic column in this area as indicated by this study shows that all of the rock above Elevation 31± is part of the Trempealeau formation. The upper part of this formation is the Jordan sandstone member found above Elevation 55±. Between Elevation 55 and 45±, there is a Lodi member which is mostly a dolomitic and shaley silt stone. This is generally rather weak and has a thickness of about ten feet. Above Elevation 31 there is a layer of dolomite(commonly called limestone), which is about fourteen feet thick. It is called the St. Lawrence member. Occasionally, it is slightly green in color because of the presence of glauconite.

Below Elevation 31±, and at the tunnel location, is the Franconia formation which consists of sandstone. This is predominantly made up of sand. However, it contains some dolomite beds and has a large amount of glauconite which gives it a green color in many places. This formation has numerous old animal burrows in it which sometimes are found filled with yellow sand or silt. The over-all thickness of this formation is about seventy to one-hundred and twenty feet. It is to be expected that the tunnel will be constructed for the most part in the Franconia formation.

Because of the possibility of different layers of dolomite and other variations within this formation, it was felt necessary to core at several places to examine its condition.

There are no known abnormalities, such as faulting, dipping, or channeling in this area, and it is expected that there is a southerly dip of the rock bed of about ten to fourteen feet to the mile. Therefore, the elevations at the various changes from one formation to the next, as given above, are only approximate.

The over-burden soil in this area is formed mainly from glacial deposits. Most of the rock north of the railroad is covered with ground moraine and terminal moraine deposits. Along University Avenue and the railroad, the over-burden soil is generally a lacustrine deposit containing silts and fine sands.

SUBSURFACE EXPLORATION METHODS

Ordinary soil borings were performed in the over-burden over rock, at certain locations only. These were made by standard methods (ASTM Tentative Designation D 1586-64T), using a 2-inch outside diameter split spoon sampler driven with a 140-lb. weight falling thirty inches. The number of blows required to drive the split spoon sampler twelve inches is recorded on the log of borings and is an indication of the relative density of granular materials and the consistency of cohesive materials encountered. The borings were advanced by driving casing and wash boring as required between sampling points. The logs of these borings are shown on the attached Drawing C 1986-1. Each boring into the tunnel zone extended to two feet below the tunnel invert.

Where bedrock was encountered and the distance to the tunnel was not considered excessive, the rock was cored using a 2-inch diameter core barrel fitted with either a diamond bit or a carbide cutting bit, depending upon the rock to be cored. At one location, where no rock recovery was being obtained, a double tube core barrel of EX-size (7/8-inch core) was used. Generally, a double tube core barrel will give somewhat better core recovery than a single tube core barrel, depending upon the material being cored.

Because of the difficulty in obtaining cores of sandstone rock, wash samples were obtained from the cuttings coming out of the hole or samples were obtained by driving a split spoon in the bottom of the boring. In other instances, samples of rock cuttings were obtained by driving an open pipe at the bottom of the cored hole.

The zone of greatest interest with respect to tunnel design and construction is that in the vicinity of the tunnel and just above it. Therefore, that rock well above the tunnel would not have to be cored. Only generaly information about this rock is needed for design and construction. To reduce the cost of this exploration program, we brought in a quarry drill. This was used to extend the borings quickly down through rock to a zone somewhat above the top of the tunnel and then the boring was continued downward using coring methods as described above. The quarry drill operated very rapidly and all work was completed in less than a day. Several quarry drill holes were put down, although not all of these holes were utilized in coring later on. A very general description of the rock penetrated by the quarry drill was obtained in the field and this is shown on the boring logs (Drawing C 1986-1). This agrees both with the rig boring work in nearby locations and with the geology information.

SUBSURFACE CONDITIONS

Over-burden materials in this area correspond with the geologic descriptions given previously herein. Along the south leg of the storm sewer adjacent to the railroad, no bedrock was found in the eastern part of the line as represented on Borings 1 and 2. The subsurface soil conditions here consist of a layer of stiff brown clayey silt, underlain by a dense deposit of light brown fine silty sand.

Evidently the over-burden soils overlying rock throughout the rest of the line consist predominantly of silt over sand. Some of this sand may have been derived from the bedrock found at higher elevations.

Between Borings 2 and 3, the bedrock surface will be encountered during construction of the storm sewer.

The bedrock along the tunnel alignment is approximately as described in the geologic report. The highest rock, that is found above Elevation 55, is a sandstone of the Jordan member of the Trempealeau Formation. In most cases, this was penetrated by the quarry drill with ease. The next lower Lodi member was easily penetrated by the quarry drill also, and this is described on Borings 8 and 10 as a limestone and sandstone combination containing clay seams. (For information of those using USGS datum, add 845.6 to City datum to obtain USGS datum.)

The St. Lawrence member of the Trempealeau Formation was found to be a rather sound limestone formation (technically called dolomite). The rock soundness as indicated in the various places where it was cored and by the progress of the quarry drill is rather good. The higher the percentage of recovery of cored rock, the sounder the rock. Anything over 50% recovery generally indicates a sound condition. Therefore, this rock can be described as a rock which will arch over a tunnel to a great extent and permit reduced pressure in designing the tunnel lining.

The Franconia sandstone formation was drilled with the quarry drill and also cored with the coring equipment. Very little rock recovery was obtained when coring. The best core recovery was found in the upper part of this formation as shown in Borings 3 and 4. Therefore, it can be expected that as one proceeds into this sandstone formation from the south towards the north and at increasingly deeper elevations the degree of cementation will be less and less.

The low rock coring recovery percentages are an indication of the low cementing ability of the binder that holds the sand grains together in this rock formation. Normally, in Wisconsin it is not expected that coring of sandstone will produce any rock recovery when using a single tube core barrel. Sometimes in using double tube core barrels sandstone formations can be sampled to some extent.

It is the practice of many organizations, including the Wisconsin Highway Commission, to drill into sandstone formations using fish tail bits, or equal, and then attempt to sample the rock using the split spoon sampler. On this work, when it was found that little or no recovery was being obtained at lower elevations, samples of the "rock" were obtained using whatever method that was most suitable at the time. From this work and examinations of the coring recovery, it is concluded that the Franconia Formation that will be penetrated by this tunnel is weakly cemented and may be described as a weak rock for tunnel design purposes. Excavation into this formation can be performed with power equipment, but progress will be quite slow. This rock is by no means so loosely cemented that the rock can be considered equal to a dense sand soil. The very high split spoon blow count

information shown indicates the cementation is fairly strong. The cementation breaks down by mechanical action and by dissolving action in water.

There is a gap in information between Borings 7 and 11, which could be explored by additional coring, if necessary, because the upper zones of Borings 8, 9, and 10 have been already drilled by the quarry drill. However, because of the uniformity of information as provided in the various core borings, it is not felt that additional coring between Borings 7 and 11 will be needed.

Examination of the Franconia Formation, as exposed at the outlet location on the shore of Lake Mendota, reveals a weak sandstone. This sandstone is interspersed with two sand layers which do not have any binder. For a visual indication of perhaps the poorest rock that is to be expected in the tunnel, the contractors should be asked to examine this exposure before bidding.

It will be noted on the logs that a large amount of water was lost during the coring operations. At times no water returned to the ground surface. It is felt that most of this water was lost by seepage into both the sandstone and limestone formations being cored. It is also noted where the water level readings after coring are highly variable. This indicates that part of the tunneling work will be without any water problems and that water possibly will be encountered in minor quantities at intervals. It is felt that there will be only minor ground water problems during construction above the lake level. Lake level presently is near Elevation +4+.

However, as the tunnel proceeds below lake elevation, the porosity of the sandstone is likely to require the increased use of pumps in order to continue construction towards the lake below lake level. In any case, the water probably will not impede construction to any significant extent.

DESIGN OF TUNNEL FOR TEMPORARY AND PERMANENT LININGS

For design purposes, it is suggested that all rock be considered as weighing about 165 pounds per cubic foot. Overburden soil should be considered as weighing approximately 130 pounds per cubic foot. The safety factor used in the design of tunnel linings should be at least 2. Where there is question as to adequacy in weaker rock areas, a higher safety factor is required.

It is very difficult to estimate accurately the pressure that will be exerted on tunnel linings. This rock contains weak beds and, therefore, a conservative approach should be followed. For temporary linings, before concreting is performed, it is generally suitable to design the liners to carry a downward load equal to the weight of that material found within a certain distance above the tunnel. The rest of the material above that point is considered carried by the rock on the side of the tunnel by arching action. For strong sound rock, the height of arching is very slightly above the ceiling. For solid high strength rock, no temporary lining generally is needed. On this job, where the tunnel will be in a variable strength sandstone formation, we suggest that a tunnel liner be employed which will carry that material within a height above the tunnel equal to one tunnel diameter as a minimum.

The Wisconsin State Industrial Commission will control the minimum standards for this bracing. They may permit bracing in the tunnel for the roof only, where the rock in the walls will permit reduced bracing. Experience in sandstone tunneling in Wisconsin is very limited. Therefore, the work probably will have to proceed on a trial and error basis until it is readily apparent how much temporary bracing actually is needed.

To avoid on the job problems of responsibility for cave-ins, the City may elect not to specify any minimum temporary bracing requirements, but should insist that the contractor "use sufficient strength bracing at a suitable spacing so as to prevent failure of the tunnel roof". Then responsibility for the work is left with the contractor and only he and the Industrial Commission need be concerned with the amount of bracing.

For permanently supporting the load of soil and rock above the tunnel, it has been found in soils consisting predominantly of clean sands, that the permanent load will not increase beyond that load exerted by a volume of material above the tunnel a height equal to three times the tunnel diameter. Since the rock conditions above this tunnel generally are better than a sand soil (without any binder), use of a design procedure wherein the load to be carried is considered as that material within this zone (3 x D) times a safety factor, probably will be adequate. We suggest a safety factor of at least 2. Thus, the unit downward pressure to be resisted is 6.5 x 3 x 165 x 2 = 6,400 lbs./sq.ft.

To minimize increase in load on the tunnel after the tunnel is completed, it is suggested that all voids outside the temporary tunnel liner be filled in by blocking and grouting. This will prevent rock movement (which otherwise will add to the load on the tunnel).

It is also suggested that the temporary tunnel liner be made water-tight so as to prevent erosion of the sandstone adjacent to the liner in areas where ground water seepage is encountered.

A common problem encountered when tunneling through some rock is a swelling or squeezing condition. This is commonly caused by rock containing expanding clay minerals, such as montmorillonite. Such a condition is not expected here. Therefore, horizontal loading will not be critical (if the vertical load is used in the design of ring reinforcement).

The type of lining should be specified in two alternates, if possible, as either concrete or liner plate with a paved insert. It is highly possible that liner plate will make a satisfactory temporary liner which also will be suitable as a permanent liner.

SUMMARY

There will be a minor change in rock cementation conditions from the south end of the tunnel to the north. All of the tunnel work is expected in the sandstone of the Franconia

Formation. This rock is exposed at the lake shore and its condition there is typical of the poorest conditions to be expected in the tunnel.

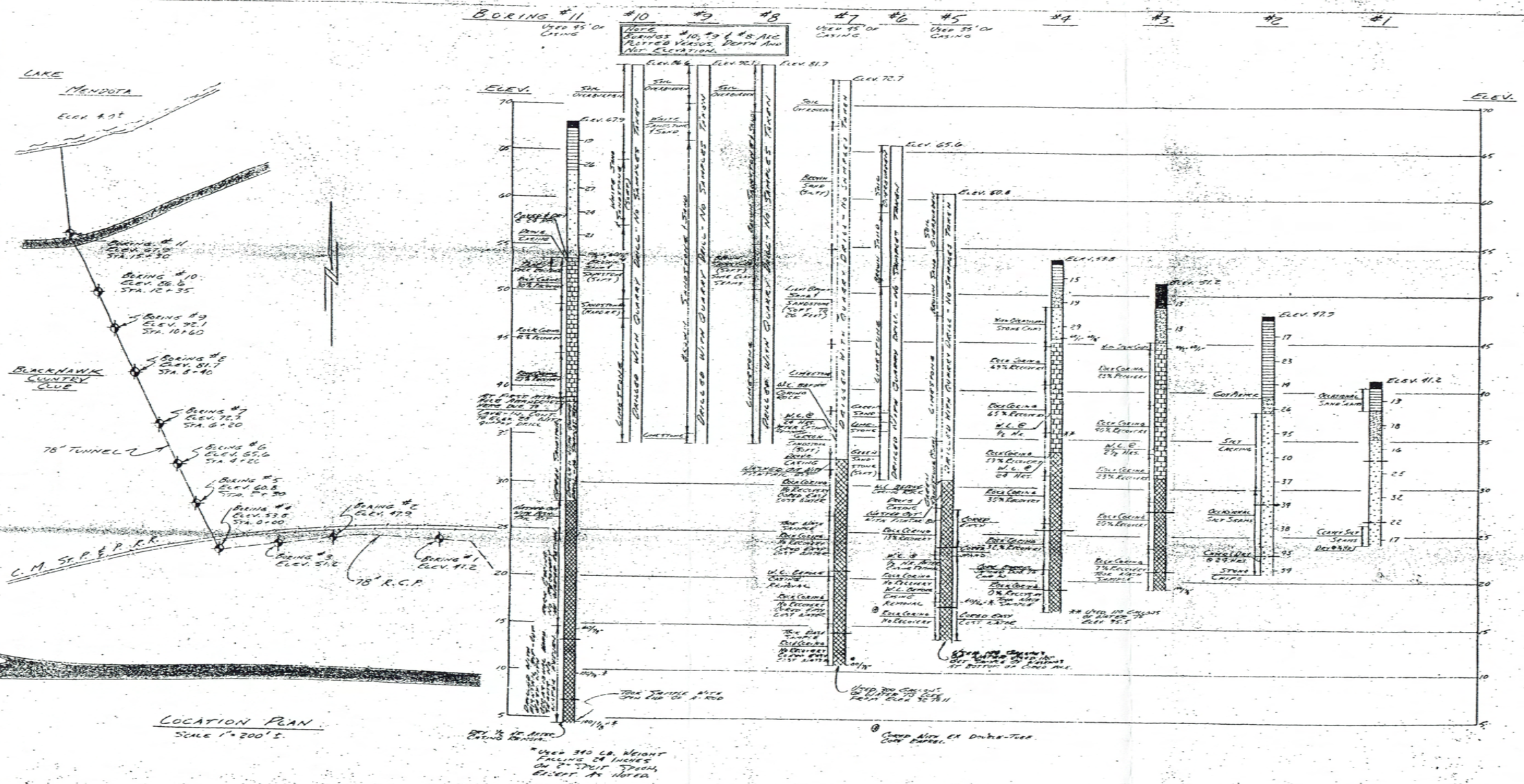
Very truly yours,

WARZYN ENGINEERING & SERVICE CO., INC.

Clifton E. R. Lawson
Professional Engineer

Willard W. Warzyn
Professional Engineer

CERL:mds



LOCATION PLAN
SCALE 1" = 200' ±

LEGEND

- TOPSOIL
- BROWN CLAYEY SILT
- BROWN CLAYEY, FINE TO MEDIUM SAND
- LIGHT BROWN SILTY FINE SAND
- SANDSTONE (GREEN & BROWN)
- LIMESTONE

NOTES

1. ELEVATIONS OF SOIL BORINGS WERE FURNISHED BY CITY OF MADISON ENGINEER'S OFFICE. ALL ELEVATIONS ARE CITY DATUM.
2. BORINGS WERE MADE USING STANDARD PROCEDURES WITH A 2-INCH O.D. SPLIT SPOON AND 2½-INCH CASING AS REQUIRED.
3. FIGURES TO THE RIGHT OF EACH BORING LOG INDICATE THE NUMBER OF BLOWS REQUIRED TO DRIVE THE 2-INCH O.D. SPLIT SPOON 12 INCHES USING A 140-LB. WEIGHT FALLING 30 INCHES.
4. NOTATION "DROVE CASING" INDICATES DEPTH TO WHICH BORING HAD PROGRESSED WHEN CASING WAS FIRST USED.
5. WATER LEVELS (W.L.) INDICATED WERE AT TIMES SHOWN AFTER COMPLETION OF THE BORINGS.
6. NOTATION "CAVED & DRY" INDICATES DEPTH WHERE HOLE HAD CAVED IN AND WAS DRY AT TIME SHOWN AFTER COMPLETION OF THE BORING.
7. ALL CORING WITH 2" SINGLE-TUBE CORE BARREL EXCEPT BOTTOM FOUR FEET AT BORING NO. 5 WHERE A DOUBLE-TUBE EX CORE BARREL WAS USED.
8. TOP & BOTTOM OF TUNNEL SHOWN AS HEAVY DASHED LINE — —.

SCALE
VERTICAL - 1"=5'
HORIZONTAL - NONE

WISCONSIN
WILLARD W. WARZYN
MADISON, WIS.
PROFESSIONAL ENGINEER

LOG OF SOIL BORINGS
FOR
PROPOSED ROUTE OF UNIVERSITY AVE.
WEST END RELIEF STORM SEWER
MADISON, WISCONSIN

WARZYN ENGINEERING & SERVICE CO.
MADISON, WIS.

DWN. BY T.E.D., G.B.H. APPD.: [signature]
CHK. BY C.A.S., C.L. DATE: 8/12/65
SCALE AS SHOWN

C1986-1

PRINT ISSUED APR 29 1968

APPENDIX D
PUBLIC COMMENTS

STORM WATER MANAGEMENT MEETING
December 12, 2000

A storm water management and lake quality citizens group conducted a public forum at the Village Hall on the evening of December 12, 2000. This forum was posted as a Village Board meeting so that Village Board members could attend and participate. In attendance were President James Thomas, and Trustees Peter Hans, Brian Joiner and Marilyn Townsend. Sherrie Gruder served as moderator. About 35-40 people attended the meeting.

The panelists were:

- David Wolmutt, engineer for Strand & Associates, the engineering firm that conducted the 1997storm water management study that recommended the storm water tunnel
- Ken Potter, UW Professor, Civil & Environmental Engineering
- Richard Lathrop, UW Honorary Fellow and DNR Limnologist
- Kevin Connors, Dane County Conservationist
- Ken Johnson, DNR Lower Rock River Basin Water Team Supervisor

David Wolmutt, the first speaker, began by discussing the creation of the 1997 report.

The focus of that study, funded by the Village and the City of Madison, was **flood control for a 100-year storm event Water quality was not a consideration.** Flooding factors considered include the extent of the watershed, peak discharge amounts, the adequacy of existing storm sewers, and various alternatives. Numerous alternatives were considered, such as flood proofing, retention of storm water at Rennebohm and Lucia Crest Parks, underground detention, and the construction of a culvert parallel to the existing box culvert that runs to Willow Creek. There are advantages and disadvantages to each of these alternatives. Strand's conclusion was that the most cost effective method of controlling the storm water from a 100-year storm event would be to construct a **storm water relief tunnel** from the intersection of University Avenue and Midvale Boulevard, passing beneath Blackhawk Country Club, and discharging into Lake Mendota near the Village marina.

Mr. Wolmutt said that measures could be taken to flood proof the homes in the Garden Homes area, but those measures will not solve the flooding problem on University Avenue.

As for concerns about lake quality from direct storm water discharge, Mr. Wolmutt noted that the best area for treatment of the storm water would be at Willow Creek. [Willow Creek currently runs from the UW west campus heating plant, alongside the Natatorium, and into University Bay]. So, if the 100-year flood tunnel were constructed, the "first flush" of storm water would still flow east using the existing 9 by 12 foot box culvert [which discharges into Willow Creek]. Only a "second flush" of water would be carried to Lake Mendota via the relief tunnel. In addition, more extensive filtration measures have been required at the entrance to the storm water drains in the redeveloped Kohl's shopping center site. However, it was pointed out by Dr. Lathrop, that nutrients and sediment are pervasive in the second flush and that all filtration benefits through Willow Creek and an upgraded marsh would be lost with a tunnel.

Mr. Wolmutt reported that currently the Village and the City of Madison are working on developing a cost sharing agreement for the relief tunnel. Strand & Associates, under contract to the Village, is also working on an environmental assessment of the relief tunnel, with expected submission to the

DNR in early 2001. Strand has worked with Flad Development Corporation to obtain easements for the storm water chamber needed to construct the relief tunnel. Finally, Strand is working with the Village on measures to flood proof the Garden Homes area and is beginning to explore the possibility of detaining some of the storm water from the west on Blackhawk Country Club north of the railroad tracks.

The second speaker was **Professor Kenneth Potter.** Professor Potter read a prepared statement, a copy of which is . The main points of his presentation: "...the Strand analysis was unduly constrained by the selected design standard: control of runoff from a 100-year storm"; "Garden Homes can be protected without a diversion tunnel"; and "there are **other strategies** which will be more cost effective and also provide much needed water quality benefits." Professor Potter then invited questions from the audience.

A Village resident asked whether there had been three 100-year storm events recently. Professor Potter said that he doubted that. Mr. Wolmutt said that the June 2000 flood was the result of a 25-year storm event, but that the ground was so saturated from earlier rains that the effect was a 25-50 year storm event.

Another resident asked whether storm water could be retained or detained on the golf course. The panel responded that it could. Moreover, storm water can be detained in parking lots and other areas. Detaining water in a large number of small areas may have a substantial result in alleviating storm water flooding. A resident asked if Merrill Springs Park, next to the golf course and, he believed, 6 feet lower than the Kohl's lot, could be a detention area. Strand responded that it didn't survey that area.

A village resident that lives on Burbank Place asked whether a cost-benefit analysis had been conducted to take into account the more frequent flooding events that have occurred during the last decade. Professor Potter responded that the cost-benefit allocation is, essentially, a political decision.

Another Village resident noted that, with the construction of the bike path, storm water continues to run east, rather than to the west. Mr. Rob Ehlers, from Strand, stated that at the time the bike path was designed, the Department of Transportation told Strand that storm water drainage could not be changed in a way that impacted the foundation for the railroad tracks. He pointed out that Strand is looking at storm water detention on the golf course, with storm water being carried to the north under the tracks.

Ms. Gruder asked whether the goals of the Village should be expanded from a 100-year storm event and Professor Potter said that they should be. He noted that the 100-year storm event standard should be applied only to Garden Homes and could be accomplished without a tunnel, but was not the appropriate standard for the rest of the area. In addition, he stated that both flood relief and lake quality benefits could be attained at a lesser cost by a number of means. Ms. Gruder followed up by asking where the Village should go from here. Professor Potter said that the Village needed cooperation from others, such as the City of Madison, Dane County, the State of Wisconsin DOT, and owners of large impervious surfaces (such as Hilldale Shopping Center), and that a work group needs to be formed. Professor Potter is willing to help the Village (without cost) in its efforts to manage storm water.

Professor Potter then needed to leave to teach a class.

The next speaker was **Richard Lathrop**. Dr. Lathrop is an expert in lake quality and has studied and made extensive records of Lake Mendota for 20 years. He supplemented his comments with a slide presentation.

Mr. Lathrop observed that Lake Mendota is a valuable asset worth $100's of millions, but that value is adversely affect by large **algae blooms**. The phosphorus that causes these blooms comes primarily from non-point sources – broad based agricultural and urban runoff, rather than from a single source. The largest urban inputs come from the south shore of Lake Mendota. Lake Mendota has been designated as a priority watershed area by DNR – that is, it is DNR priority to help take actions to reduce the pollution going into Lake Mendota. The project is focusing on reducing phosphorus and sediment flowing into the lake. If the amount of phosphorous flowing into Lake Mendota can be reduced by 50%, then [the unpleasant] algae blooms will occur on only 2 out of 10 days, rather than the current 6 out of 10 days. This is a goal the County is focusing on.

The next speaker was **Mr. Kevin Connors**. Mr. Connors also supplemented his presentation with a slide show.

Mr. Connors discussed the creation of the **Lake Mendota Watershed Project** in 1993 and the implementation plan which was approved in 1997. Phosphorous runoff and sediment loads coming from various types of use have been studied and were discussed by Mr. Connors. The implementation plan calls for a reduction of 50% in both phosphorous and sediment flowing into Lake Mendota. If that goal is reached, then four out of five days will be free of nuisance algae conditions.

Mr. Connors discussed the phosphorous and sediment reduction goals for developed areas like Shorewood Hills. From those areas, Phosphorous runoff must be reduced by at least 20%, and sediment flow must be reduced by 40%, if the watershed is to reach its overall goals of 50% for each.

Mr. Connors also discussed the creation of the Dane County storm water management ordinance. That ordinance has not yet been enacted [public hearings began in January 2001], but would call for such measures as storm water containment, sediment control filtration of oil and grease, and diversion of water away from driveways, parking lots and other impervious surfaces.

Mr. Connors also discussed proposed DNR nonagricultural storm water runoff standards (DNR regulation 151, subchapter 2). Drafting of these standards continues and more public hearings will be held late spring/early summer 2001.

In sum, there are or will soon be tightened watershed, county and state laws regarding runoff into lakes and streams.

The final speaker was **Mr. Ken Johnson from the DNR**. He is the DNR water team leader for the Lower Rock River Basin, which includes both Lake Mendota and the Village of Shorewood Hills.

Mr. Johnson first discussed some **regulations pertaining to storm water**. He understands the Village, in conjunction with the City of Madison, is set to begin a storm water permitting process for the storm water tunnel. Approval of a permit will require the adoption of best management practices. In addition, the Village will need to consider NR 216, currently in draft form. That regulation will require that performance standards for the reduction of solids and phosphorous be adopted. Municipalities will need to be in compliance by 2008. Critical sites have been identified by the DNR.

At those sites, reductions will be mandated. The area in which the Village is located will probably be considered a critical site.

In addition, a storm water relief tunnel, is the type of structure subject to regulation under Chapter 30. The Village must apply for a permit under section 30.12. While the project has been discussed with Village officials and representatives from Strand, an application has not yet been filed. If an application is filed, then the DNR will inspect the site and determine whether an environmental assessment is needed. Mr. Johnson said that it most likely would be required for this project. A 30-day public notice period would then follow, during which objections can be made (including objections that the DNR might have). If objections exist, then the DNR will most likely assume that a hearing is needed. A hearing examiner would issue a decision as to whether or not to allow the permit. That decision would be subject to court review. Mr. Johnson observed that the permit could be granted, granted with conditions, or denied. The standard to be applied is whether the project will have a detrimental effect on the public interest (in this case, Lake Mendota, including water quality, fish habitat etc.).

Mr. Johnson then discussed some of the **grants available** to the Village relating to water quality. First, up to $200,000 in funding might be available under the targeted runoff management program. The Village would apply in the summer. Second, funds are available under the urban non-point program for both planning and implementation measures. Third, lakes planning grants are available, with the State of Wisconsin funding 75% of the cost of planning, and the deadlines for application are February 1 and May 1. Fourth, up to $200,000 may be available under a lakes protection grant, and the application deadline for that grant is May 1. DNR staff will help the Village to prepare grant applications.

The panel and audience then engaged in a question and answer session.

A question was asked whether the storm water that would flow through the relief tunnel could be treated. Mr. Wolmutt said that some filtration could be done in the area of the outlet, especially if the tunnel could be used for retention. In addition, restoration of the proposed outlet area would reduce the sediment that runs into the lake through the gully near the marina. Mr. Johnson noted, however, that the DNR would prefer retention above or in front of the tunnel, rather than inside it.

A Village resident commented that she could not believe construction of a tunnel is being considered, because she did not believe it would solve the flooding problem, and the storm water flowing into the lake would not be treated. Mr. Johnson responded that the relief tunnel would work, but questioned whether it would be the smartest thing to do. He said that streets do not need the same level of protection as houses. Mr. Wolmutt remarked that it should be remembered that University Avenue is a major thoroughfare and reminded everyone of the ambulance stranded in the street during the June 1, 2000 flood.

In response to a question about the need for an environmental impact statement (EIS) as opposed to an environmental assessment Mr. Johnson said that nothing in the marina area says "absolutely not" for a discharge pipe in that area, but that the issue has not been completely studied. He said that the discharge structure does not require an environmental impact statement; rather, it requires an environmental assessment. He did acknowledge that public controversy could raise a project to a higher level. Another resident stated that given that there are Indian mounds where the tunnel would go through, he thinks an EIS would be required.

Responding to another comment, Mr. Connors said that an essential question to ask is how water can be kept from getting to the intersection of University Avenue and Midvale Boulevard in the fist place. Also, we must recognize how past decisions have led to today's problems, and how present decisions will affect the future.

Another resident said that Village residents do not understand what the experts are saying. Are the experts saying that what they would like to see is a reduction in the amount of water flowing from the City of Madison into the Village and from this area into Lake Mendota? The panel responded, "Yes."

A resident from Burbank Place noted that storm water accumulates on that street before storm water flows into the neighborhood from University Avenue. He suggested that two storm water flooding solutions might be required. Mr. Wolmutt said that efforts are being made to control storm water runoff entering Garden Homes from the west.

Another resident noted that there is evidence of sediment in the lake after every heavy rain, and questioned how the Village sponsored a study that considered water quantity without considering water quality.

Ms. Gruder asked some general questions. What will be the process for investigating storm water flooding solutions? How do we expand the standard for this project so that quality of water entering Lake Mendota is included in the analysis? How will the Village arrive at the solutions? She challenged President Thomas and the trustees to answer such questions.

Panel members responded that the Village needs to work in conjunction with others, and suggested that they could help facilitate communications and meetings among the parties. Moreover, everyone needs to begin thinking about what all of us can do to reduce runoff and improve lake quality. Doing small things can have big results. Communication and public education will be required. A public education strategy needs to be devised.

The resident from Burbank Place said all of that was fine, but asked how the Village was going to solve the flooding problem in Garden Homes. The damage done to the homes of the residents is a real problem and those residents want some relief. If they are given some relief, then they would by more willing to participate in this process. He said that the residents are fed up. Mr. Connors asked whether hard data exists relating to the annual cost of the flooding or the net benefit of the solution. This is a way to evaluate the alternatives. A cost-benefit analysis might lead to the conclusion that the homes should be moved.

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ALTERNATIVES TO THE SHOREWOOD TUNNEL PROJECT

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12/12/00

The diversion tunnel proposed by Strand Associates will certainly alleviate the flooding problems in the area of the University Avenue/Midvale Boulevard intersection. I suggest, however, that there are other strategies, based on a combination of watershed detention, hydraulic improvements, and floodproofing, which will be more cost effective and also provide much needed water quality benefits.

I base my proposal on the contention that the Strand analysis was unduly constrained by the selected design standard: control of runoff from a 100-year storm. Furthermore, no consideration was given to other potential project benefits, such as water quality improvements.

Let's look at these two issues separately: the choice of the design standard and the exclusion of water quality considerations.

Strand's design was based on the 100-year storm, an event that on average is equalled or exceeded once every one hundred years. Strand only considered alternatives that met a 100-year standard. However, it is somewhat arbitrary to apply a rigid 100-year standard to a problem such as this. A more appropriate approach would be to evaluate alternatives based on net benefits.

This works in the following way. Any given flood-protection project normally consists of a collection of strategies. These might include reservoirs (in this case detention basins) that provide flood storage; levees that protect structures against flooding; drainage system improvements that move water away more quickly; diversions that route stormwater from its normal route; and floodproofing, which allows occasional flooding but reduces the amount of damages.

Typically a set of alternative projects are developed, and each is evaluated to determine its net benefit-- the difference between the project's benefit and cost. The benefit of a flood-reduction project is based on how much it is expected to reduce future flood damages. This evaluation enables us to find the project that is most economical in terms of benefits and costs.

In such an evaluation it is not uncommon to set some minimum standards for a project. For example, in this case it seems reasonable require that all projects under consideration protect the Garden Homes subdivision against a 100-year flood event. But it is not necessarily reasonable to require that there be no flooding anywhere in the project area during a 100-year event. That's because the damage due to flooding of certain portions of the project area may be much less than the cost of providing flood protection. However, Strand only considered alternatives that met a strict 100-year standard.

Given that the Garden Homes can be protected without a diversion tunnel, it seems very possible that there are non-tunnel alternatives with greater net benefits than the proposed tunnel project. This possibility should be investigated.

The second issue I would like to raise is water quality. The greatest problem facing our lakes is pollution from stormwater runoff, both urban and agricultural. In the next few years, we will need to face this problem, either because we believe it is the right thing to do or because we are required to by federal, state, or local government. The Willow Creek watershed, which is the source of the flooding considered here, contributes about 2.5% of the phosphorus entering Lake Mendota. The tunnel diversion solution will do nothing to improve the quality of the stormwater entering the lake from this watershed, and in fact might make it marginally worse. It seems foolish to spend almost 7 million dollars on stormwater management without reaping any water quality benefits.

On the other hand, there are a number of watershed practices that could be used to address both flooding and water quality problems. These include retention ponds and various infiltration practices.

In summary, before we spend 7 million dollars on a diversion tunnel, we need to carefully consider alternatives that might provide greater net flood reduction benefits while at the same time improving the quality of water entering Lake Mendota.

Not In Our Backyard!

COMMENTS ON THE PROPOSED TUNNELING OF STORMWATER THROUGH SHOREWOOD HILLS

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September 16, 2000

Tunneling of stormwater through Shorewood Hills to Lake Mendota has been proposed as a solution to a serious stormwater flooding problem at the northern end of Midvale Avenue. (Presently this stormwater flows into Lake Mendota via Willow Creek.) Viewed through the narrow objective of local flood control, this may indeed be the low-cost solution. However this solution does not address, and may actually exacerbate, two other stormwater problems of major significance-- water quality in Lake Mendota and increasing variability of lake levels and flows in the Yahara chain of lakes.

Lake Mendota regularly experiences algae blooms as a result of excess nutrients in stormwater runoff. Under the Wisconsin Priority Watershed Program there is an ongoing multi-million dollar effort to reduce nutrient runoff from both the urban and rural portions of the Yahara Lakes watershed. Diverting stormwater into Lake Mendota will likely worsen present water quality conditions, as a significant portion of the nutrients currently delivered by Willow Creek to Lake Mendota is trapped in the shallow waters of University Bay. More importantly, the opportunities for installing stormwater treatment capacity at the Willow Creek outlet appear to be much greater than at the proposed tunnel outlet. Significant reduction of nutrient delivery from Willow Creek is essential to improving Lake Mendota water quality, both because of the magnitude of the current phosphorus load from Willow Creek, and because of the symbolic importance of reducing nutrient runoff from the Madison metropolitan area.

Urbanization of the Yahara Lakes watershed has caused lake levels and Yahara River flows to become more variable. Increases in levels and flows have resulted from increases in the extent of impervious surfaces. Unless we adopt new methods of stormwater management, future urbanization will undoubtedly increase the frequency of flooding problems in the Yahara Lakes. At the same time, decreases in low flows have resulted from increases in groundwater pumping associated with urban growth. (Since the diversion of treated wastewater from the Nine Springs Treatment Plant, average flows in the Yahara River have decreased by about 40%; low flows have decreased by a much greater percentage.) During drought years, these decreases can have severe environmental consequences. Tunneling of stormwater through Shorewood Hills does nothing to reduce the variability of lake levels and river flows. On the other hand, there are options for solving the flooding problems in Shorewood Hills that would encourage the infiltration of stormwater, and hence provide a reduction in the variability of lake levels and river flows.

In conclusion, if the Midvale Avenue flooding problem is considered from a broad stormwater management perspective, tunneling stormwater through Shorewood Hills may be a bad solution.

DNR: 'Are you budgeting for long-term liabilities?'